



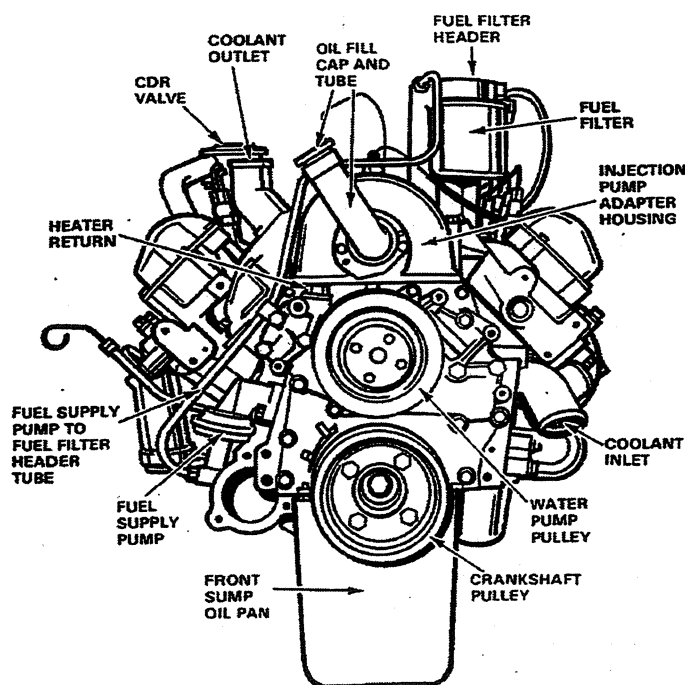
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AUTOMOBILE  
LITERATURE

# 1988 – 1993 ENGINE SERVICE MANUAL

## SUPPLEMENT 7.3 LITER DIESEL ENGINE



Due to a continuous program of research and development, some procedures, specifications and parts may be altered in a constant effort to update and improve our products.

Periodic revisions may be made to this publication and mailed automatically to dealers. It is recommended that customers contact their dealer for information on the latest revision.

# 7.3 LITER DIESEL ENGINE

Official Licensed Product

## SERVICE MANUAL

JULY 1991

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\* Procedure used when camshaft is not removed from the crankcase.

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*Ford Motor Company*

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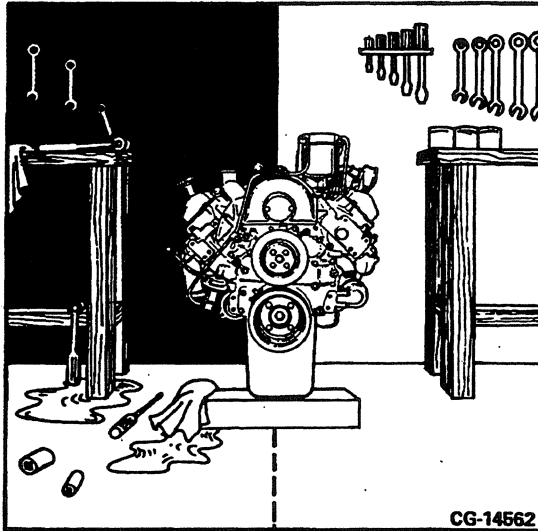
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# SERVICE MANUAL

## SAFETY SUGGESTIONS

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Page 1



Keep work area organized and clean. Wipe up oil spills of any kind. Keep tools and parts off floor. Eliminate the possibility of a fall which could result in a serious injury.

Be sure to reinstall safety devices, guards or shields after adjusting and/or servicing the engine.

After servicing, be sure all tools, parts, or servicing equipment are removed from the vehicle or engine.



Be sure to wear safe work clothing. It should be well fitted and in good repair.

Do not wear rings, wrist watches or loose fitting clothing, when working on machinery, they could catch on moving parts causing serious injury. Wear sturdy, rough-soled work shoes. Never adjust and/or service a machine in bare feet, sandals or sneakers.



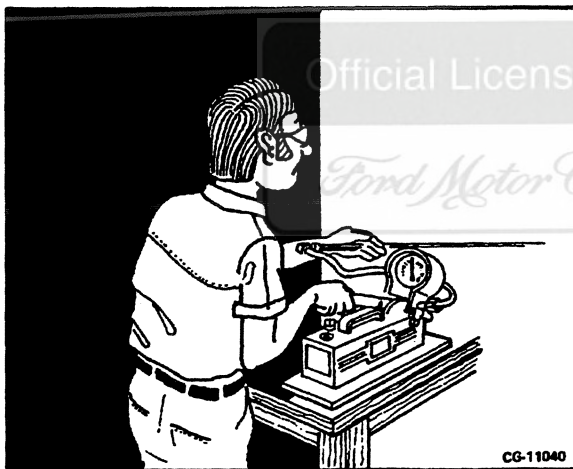
Do not use defective portable power tools. Check for frayed cords prior to using the tool. Be sure all electric tools are grounded. Severe injury can occur if electrical equipment is defective or not used properly.

## SERVICE MANUAL SAFETY SUGGESTIONS



Be careful when using compressed air. Never apply compressed air to any part of the body or clothing, severe injury can occur.

Use approved air blow guns, do not exceed 30 psi. wear safety glasses or goggles and use proper shielding to protect everyone in the work area.



Be extremely careful when dealing with fluids under pressure.

Fluid under pressure can have enough force to penetrate the skin. These fluids may also infect a minor cut or opening the skin. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can result if medical treatment is not given immediately.

Never put your hands in front of fluid under pressure.



When refueling, keep the hose and nozzle or the funnel and container in contact with the metal of the fuel tank to avoid the possibility of an electric spark igniting the fuel.

Do not over fill the fuel tank – overflow creates a fire hazard.

Do not smoke when refueling and never refuel when the engine is running.

# SERVICE MANUAL SAFETY SUGGESTIONS

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Page 3



Electrical storage batteries give off highly flammable hydrogen gas when charging and continue to do so for some time after receiving a steady charge.

Do not under any circumstances allow an electric spark or open flame near the battery or explosion may occur.

Always disconnect a battery cable before working on the electrical system.



Keep a "charged" fire extinguisher within reach whenever you work in an area where fire may occur.

Also, be sure you have the correct type of extinguisher for the situation:

Type A: Wood, Paper, Textile and Rubbish

Type B: Flammable Liquids

Type C: Electrical Equipment

# SERVICE MANUAL

## ENGINE IDENTIFICATION

### ENGINE IDENTIFICATION

7.3 Liter Diesel Engines are identified by Engine Serial Number and Engine Model Code.

The permanent engine serial number is stamped on the front top side of the crankcase. (Refer to **Figure 1** and the Engine Serial Number Chart.)

### ENGINE SERIAL NUMBER CHART

Engine Displacement	Type Code	Country of Origin	Serial Sequence Number
7.3L	DM2	U	500001*

7.3 = Engine Displacement in Liters

D = Naturally Aspirated

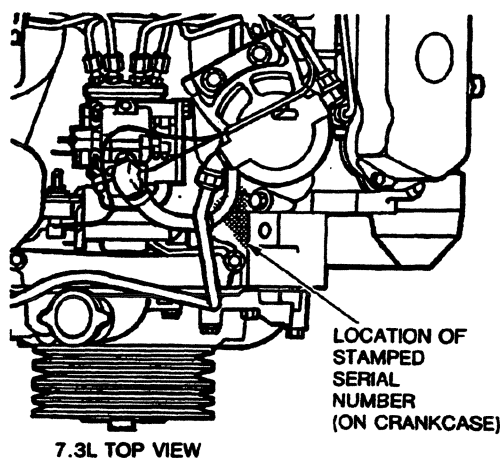
M2 = Truck Application

U = Country of Origin - U.S.A.

500001 = Starting Sequence Number

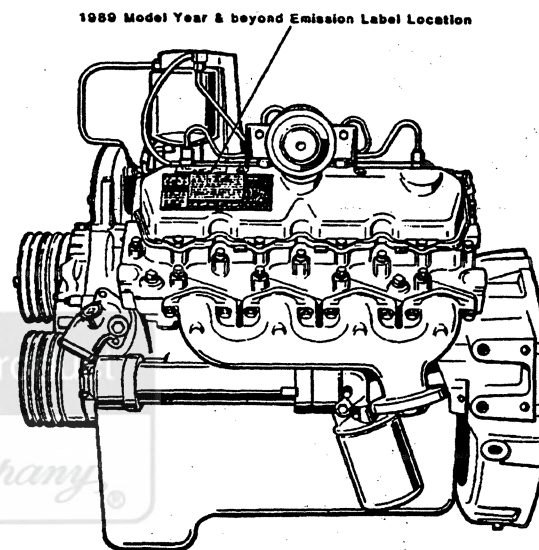
\* = Used to Prevent Tampering

The Engine Emission Label identifies the engine model code and shipping date. (Refer to **Figure 2**). The Emission Label is located on the left valve cover.

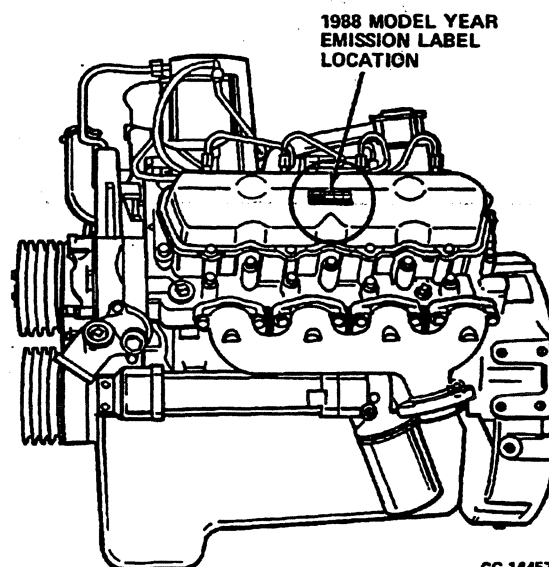


ALL 7.3 LITER ENGINES

CG-15007



CG-15006



CG-14457

Figure 1. Engine Identification Methods

● Stamped Engine Serial Number

● Emission Label

# SERVICE MANUAL


## ENGINE IDENTIFICATION

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Page 5

### ENGINE IDENTIFICATION - Continued

The Emission Label is permanently affixed to the left side valve cover. The engine model year and government jurisdiction certifications are stated on the label. The engine model is identified by a punch mark in the appropriate box.

Official Licensed Product

 <b>INTERNATIONAL</b> <b>EMISSION CONTROL INFORMATION</b> <b>RENSEIGNEMENTS DE DÉPOLLUTION</b> 7.3L ENGINE FAMILY FAMILLE DE MOTEUR 7.3L ENGINE MANUFACTURED BY: MOTEUR FABRIQUÉ PAR: <b>NAVISTAR INTERNATIONAL TRANSPORTATION CORP.</b> <b>NAVISTAR™</b> 1813344C1	<b>MODEL/MODÈLE</b>	<b>A130 ( )</b>	<b>A155 ( )</b>	<b>A170 ( )</b>	THIS ENGINE HAS A PRIMARY INTENDED SERVICE APPLICATION AS LIGHT HEAVY-DUTY DIESEL ENGINE AND CONFORMS TO U.S. EPA, CANADIAN, AUSTRALIAN ADR30, AND CALIFORNIA REGULATIONS FOR 1989 MODEL YEAR. CE MOTEUR A ÉTÉ PRINCIPALEMENT CONÇU EN TANT QU'UN MOTEUR DIESEL ROBUSTE DE GAMME LÈGÈRE. IL EST CONFORME AUX RÈGLEMENTS CANADIENS APPLICABLES À L'ANNÉE DE MODÈLE 1989.
	ADV. BHP @ RPM (PUISS. NOM. À TR/MIN)	130 @ 2700	155 @ 3000	170 @ 3000	
	FUEL RATE @ ADV. BHP, MMV/STROKE (DÉBIT DE CARB. À PUISS. NOM. MMV/COURSE)	45.3	52.0	57.5	
	INJECTION TIMING: MARKS ALIGNED. REFER TO ENGINE DIAGNOSTIC MANUAL FOR DYNAMIC TIMING SPECS. CALAGE D'INJECTION: REPÈRES ALIGNÉS. SE REPORTER AU MANUEL DE DIAGNOSTIC DU MOTEUR POUR LES SPÉCIFICATIONS DU CALAGE DYNAMIQUE. EM. CONTROL SYSTEM-SYST. DE DÉPOLLUTION: EM				
DISPLACEMENT: 7.3L CYLINDRÉE:		CURB IDLE RPM: RÉGIME DE RALENTI TR/MIN:		650 ± 50	SETTINGS MUST BE MADE WITH ENGINE AT NORMAL OPERATING TEMPERATURE, AIR CONDITIONING OFF, MANUAL TRANSMISSION IN NEUTRAL/AUTOMATIC TRANSMISSION IN DRIVE. LES REGLAGES DOIVENT ÊTRE EFFECTUÉS ALORS QUE LE MOTEUR A ATTEINT LA TEMPÉRATURE NORMALE DE FONCTIONNEMENT, LE CLIMATISEUR EST ARRÊTÉ, LA BOÎTE DE VITESSES MANUELLE EST AU POINT MORT/LA BOÎTE AUTOMATIQUE EST EN PRISE.

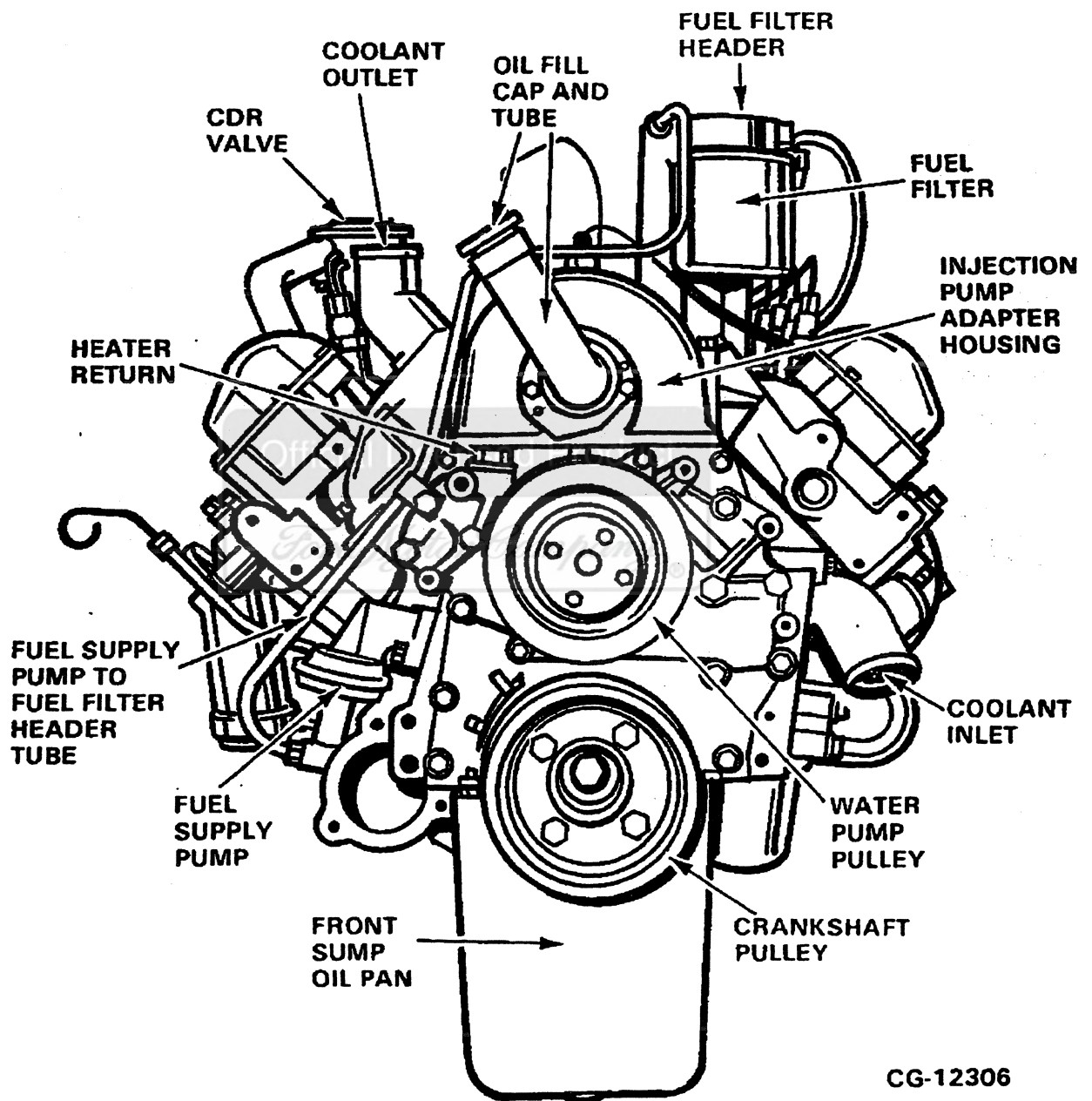
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Figure 2. Emission Label Detail  
[Typical Model Year Emission Label Shown]



# SERVICE MANUAL

## ENGINE DESCRIPTION



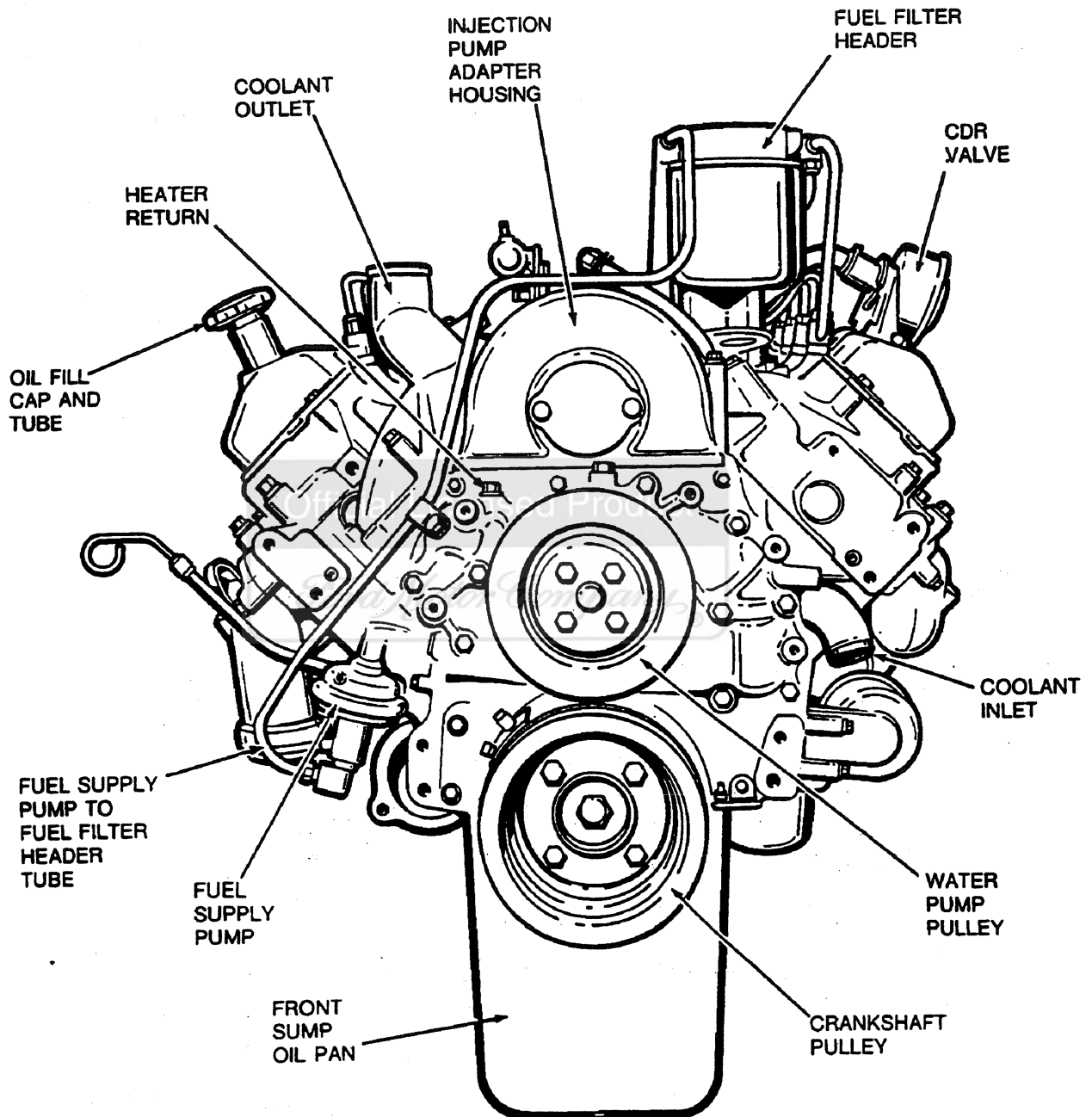
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Figure 3A. 7.3 Liter Front View  
[1988 Model Year and Earlier]

# SERVICE MANUAL

## ENGINE DESCRIPTION

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CG-15001

Figure 3B. 7.3 Liter Front View  
[1989 Model Year and Later]

## SERVICE MANUAL

### ENGINE DESCRIPTION

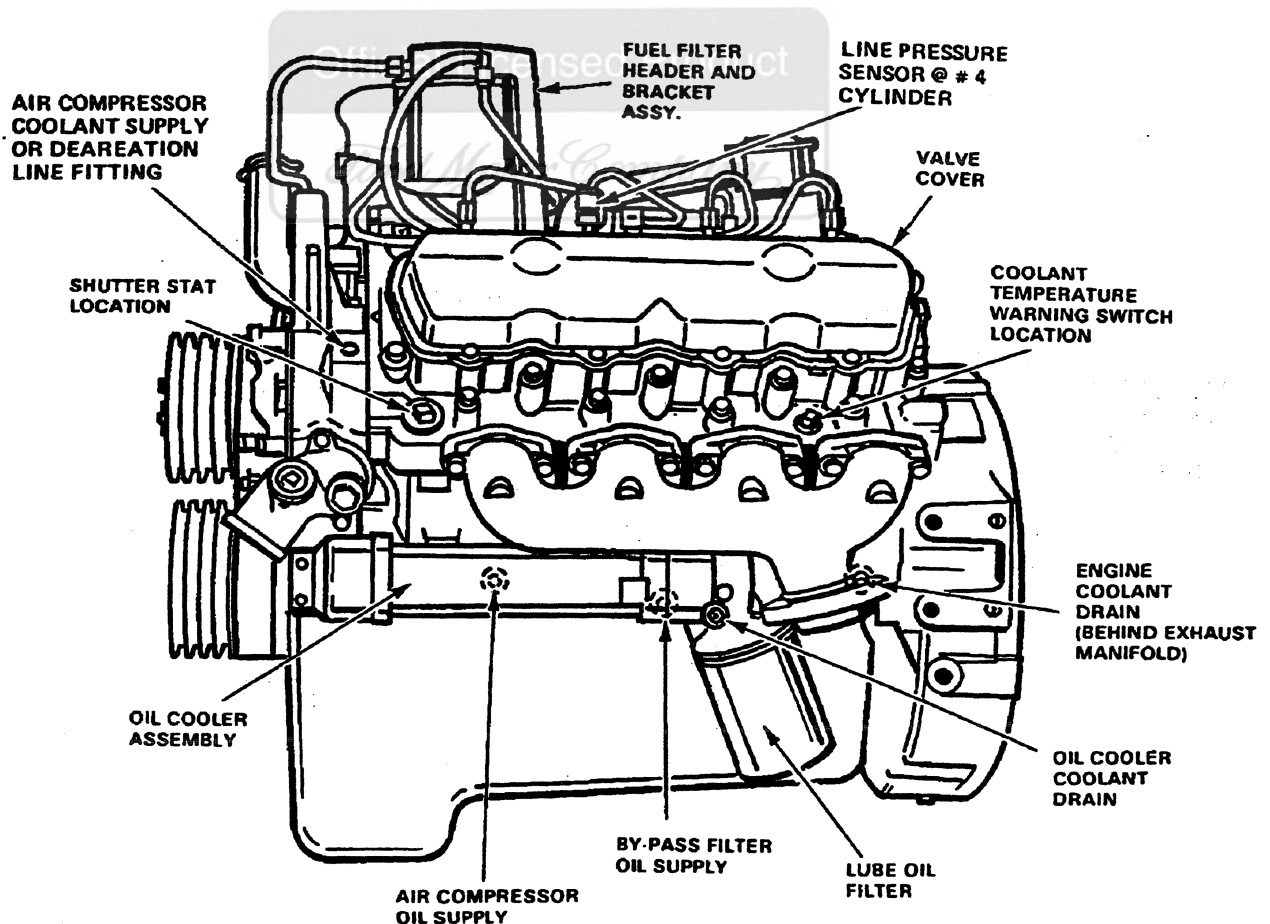
The International® 7.3 Liter Diesel Engine is a four cycle naturally aspirated V-8 with overhead valves. It has a displacement of 7.3 liter (444 cu.in.).

When viewing the engine from the rear, the right bank of cylinders are numbered 1, 3, 5 and 7 with number 1 being at the front. The firing order is 1-2-7-3-4-5-6-8.

The crankcase has been especially designed to withstand the loads of diesel operation and utilizes a four bolt main bearing to assure a rigid support for the rotating parts. The crankcase also has piston oil cooling jets which direct oil to the underside of the piston to dissipate heat.

The crankshaft is a five main bearing unit with fore and aft thrust controlled at the center (No. 3) bearing. Connecting rods are of heavy-duty construction and are attached to the crankshaft, two to each crankpin journal with the piston pin being of free floating type permitting the pin to move or float freely in piston and rod. The pin is held in place with pin retaining rings.

The camshaft is supported by five insert-type bearings pressed into the block and is driven by a drive gear keyed to the crankshaft. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and the thrust flange spacer.



CG-12307

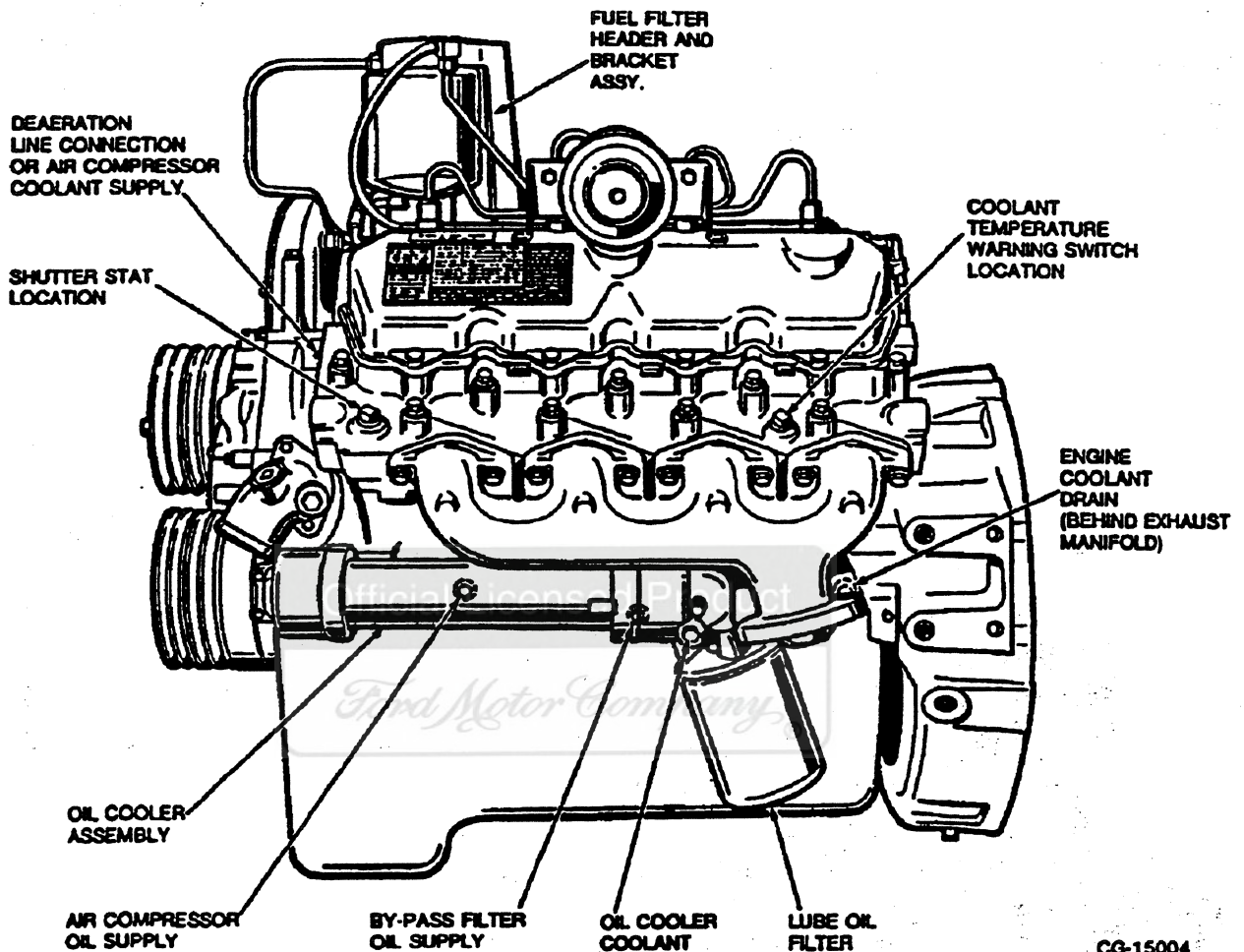
Figure 4A. Left Side View of 7.3 Liter Engine  
[1988 Model Year and Earlier]



# SERVICE MANUAL

## ENGINE DESCRIPTION

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**Figure 4B. Left Side View of 7.3 Liter Engine  
[1989 Model Year and Later]**

The aluminum-alloy pistons are fitted with two compression rings and one oil ring and are used in the engine with forged steel connecting rods.

The hydraulic valve lifters minimize engine noise and maintain zero valve lash or tappet clearance. This eliminates the need for periodic adjustment. The hydraulic valve lifters have roller followers which provide excellent camshaft durability characteristics.

The cylinder head assemblies have pre-combustion chambers, which provide superior combustion characteristics. The cylinder heads used on the engine are equipped with a positive valve rotating mechanism on both the intake and exhaust valves. This device is called a rotator and is located at the base of each valve spring.

A solid state glow plug system and block heater provide outstanding cold weather start capability.

## SERVICE MANUAL

### ENGINE DESCRIPTION

The fuel filter attaches to a header and bracket combination which mounts to the engine. A primary fuel filter and water separator is chassis mounted.

The engine is equipped with a fully closed crankcase ventilating system. Crankcase vapors are directed to the intake manifold from a port in the crankcase depression regulator.

The Stanadyne Model DB-2 Fuel Injection Pump used on the 7.3 Liter Diesel Engine is located between the cylinder heads and the intake manifold in the vee at the front of the engine. The DB-2 is an opposed plunger, inlet metered, positive displacement, distributor type pump.

The engine governor is integral with the fuel injection pump. Operating principles and service instructions for the fuel system components are given in the Injection Pump Service Manual CGES-475.

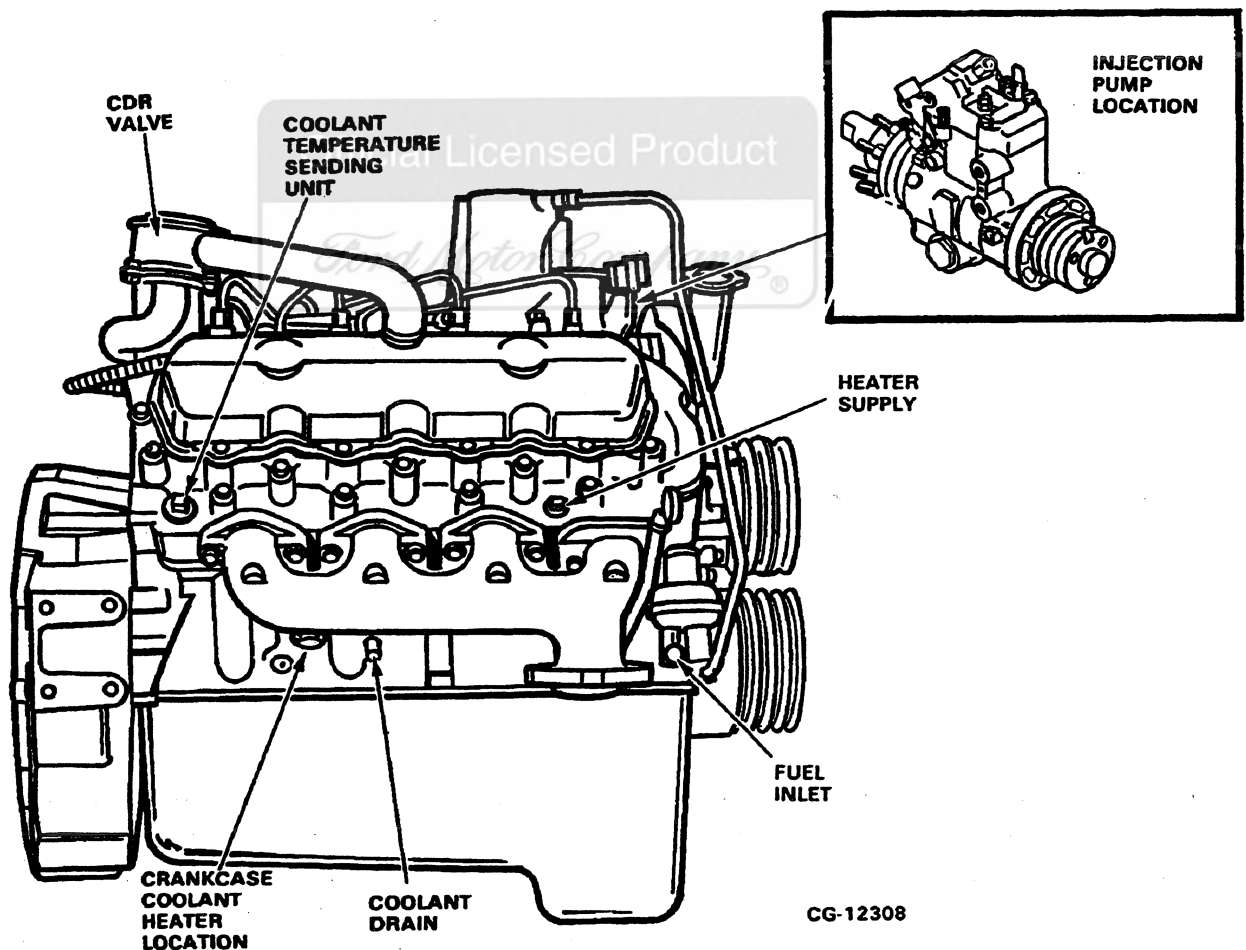
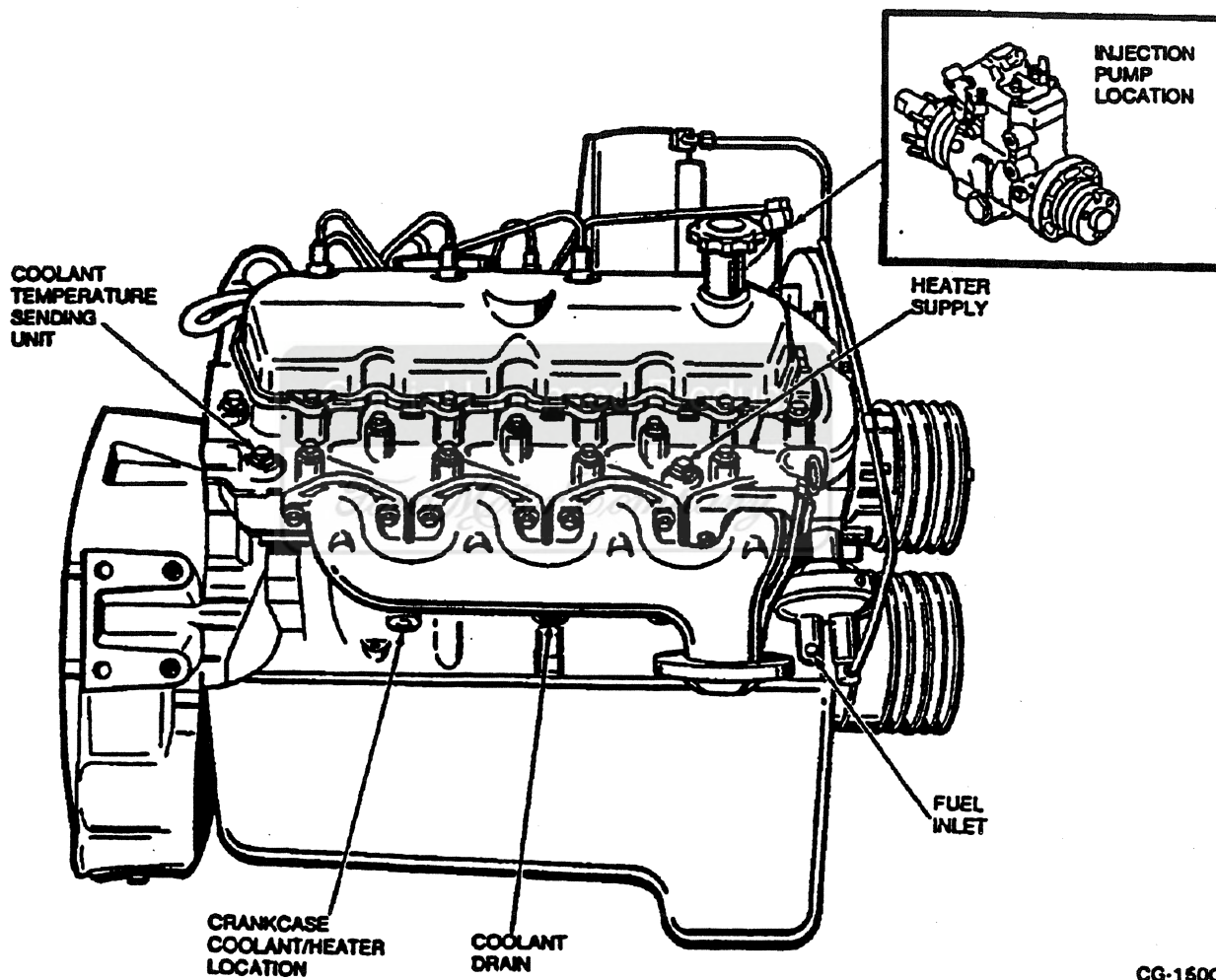


Figure 5A. Right Side View of 7.3 Liter Engine  
[1988 Model Year and Earlier]

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## ENGINE DESCRIPTION

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Figure 5B. Right Side View of 7.3 Liter Engine  
[1989 Model Year and Later]

## SERVICE MANUAL

### ENGINE DESCRIPTION

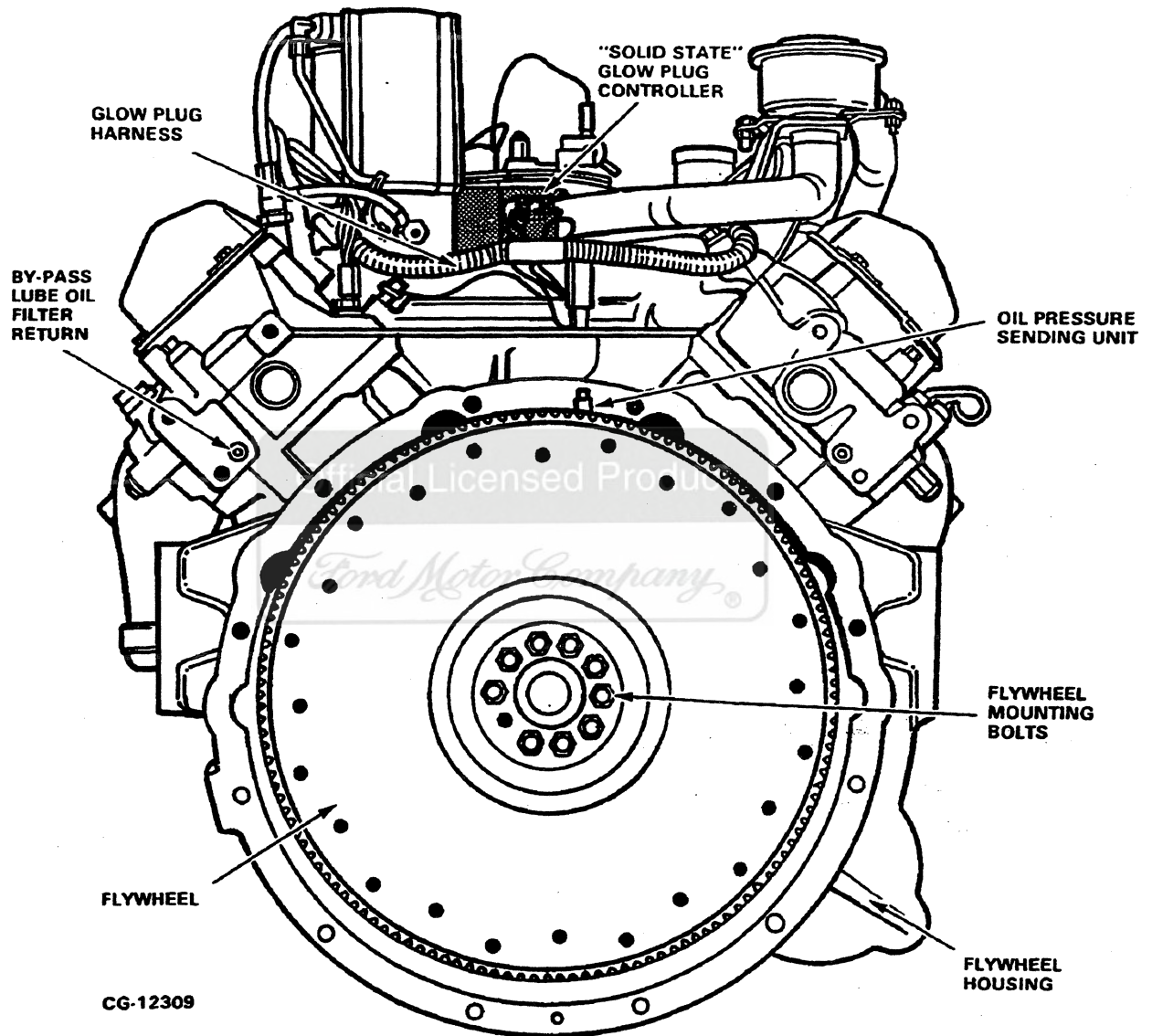


Figure 6A. Rear View of 7.3 Liter Engine  
[1988 Model Year and Earlier]

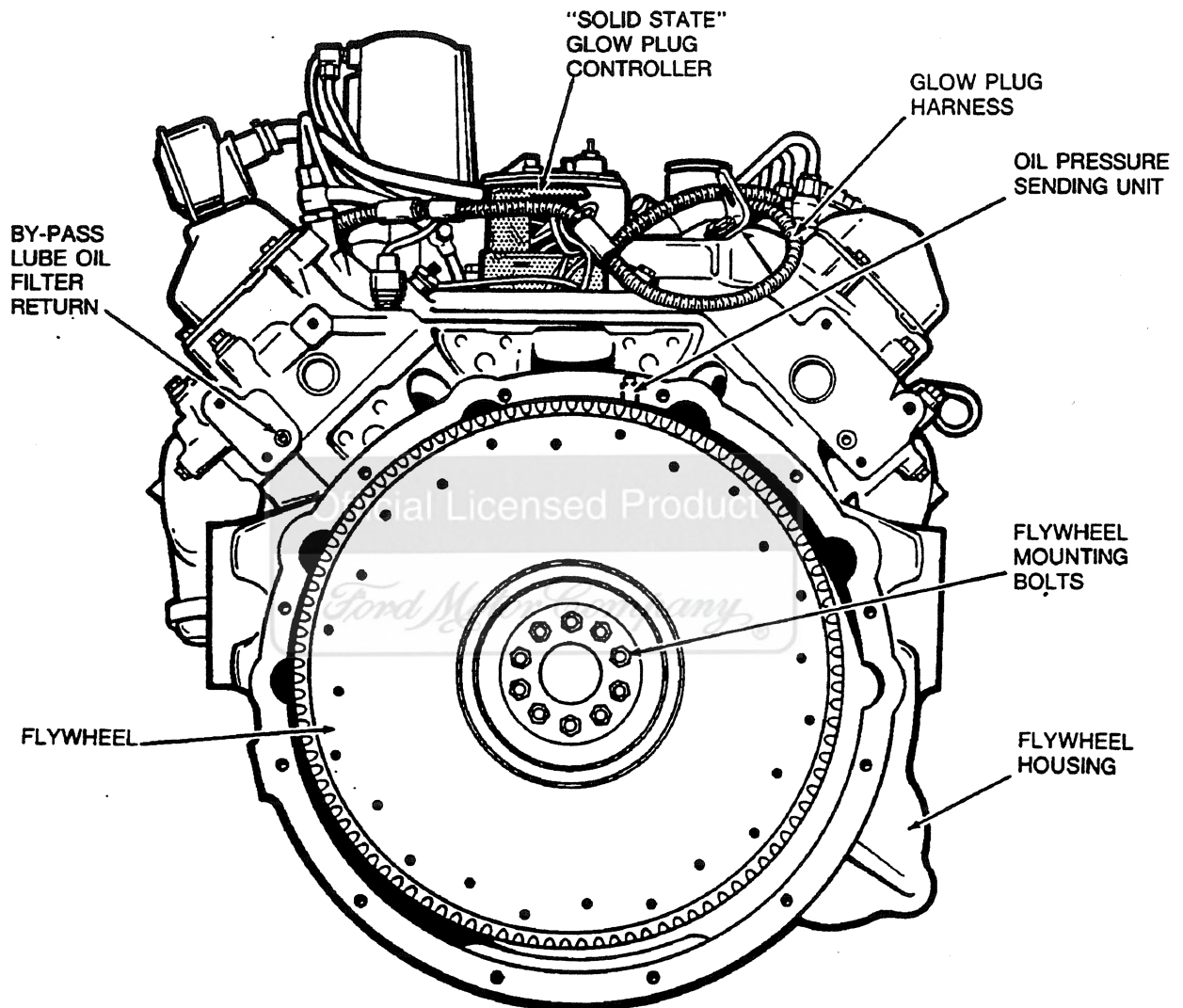
#### NOTE

Engines with automatic transmissions have a flex plate, reinforcement ring and adapter.

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## ENGINE DESCRIPTION

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Figure 6B. Rear View of 7.3 Liter Engine  
[1989 Model Year and Later]

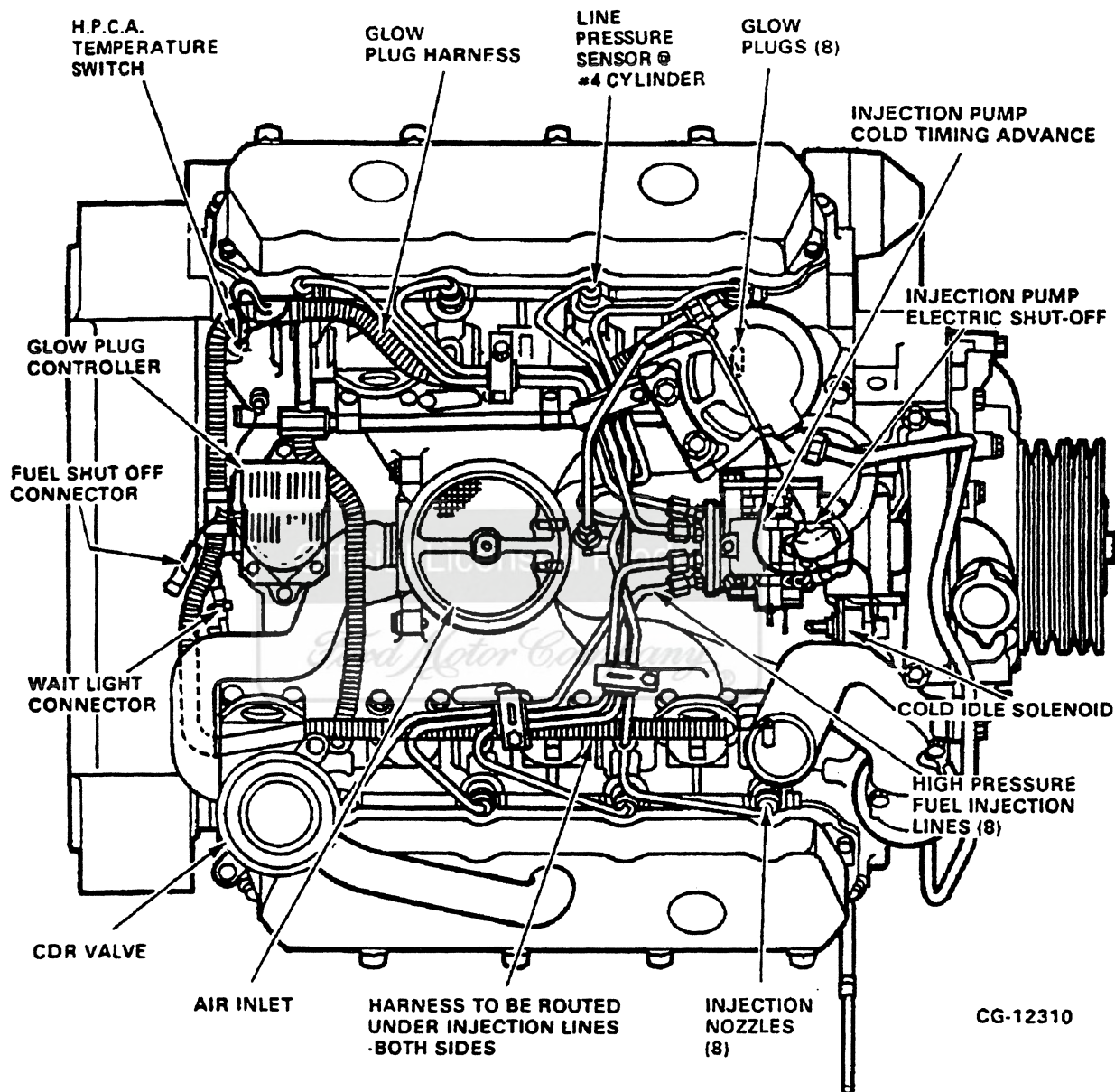
### NOTE

Engines with automatic transmissions have a flex plate, reinforcement ring and adapter



## SERVICE MANUAL

### ENGINE DESCRIPTION



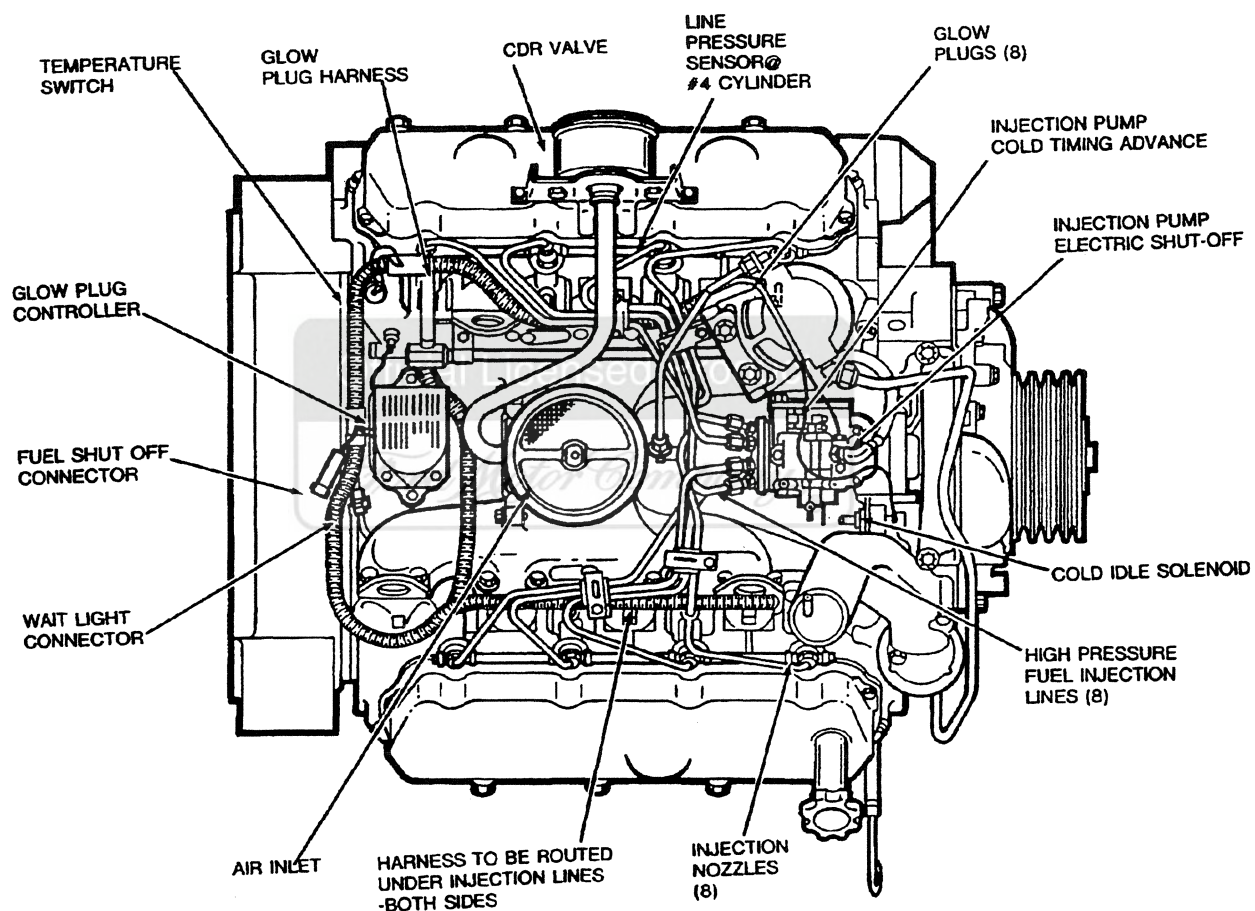
**Figure 7A. Top View of 7.3 Liter Engine Major Component Location  
[1988 Model Year and Earlier]**

The engine is equipped with a fully closed crankcase ventilating system. Crankcase vapors are directed to the intake manifold from a port in the crankcase depression regulator.

# SERVICE MANUAL

## ENGINE DESCRIPTION

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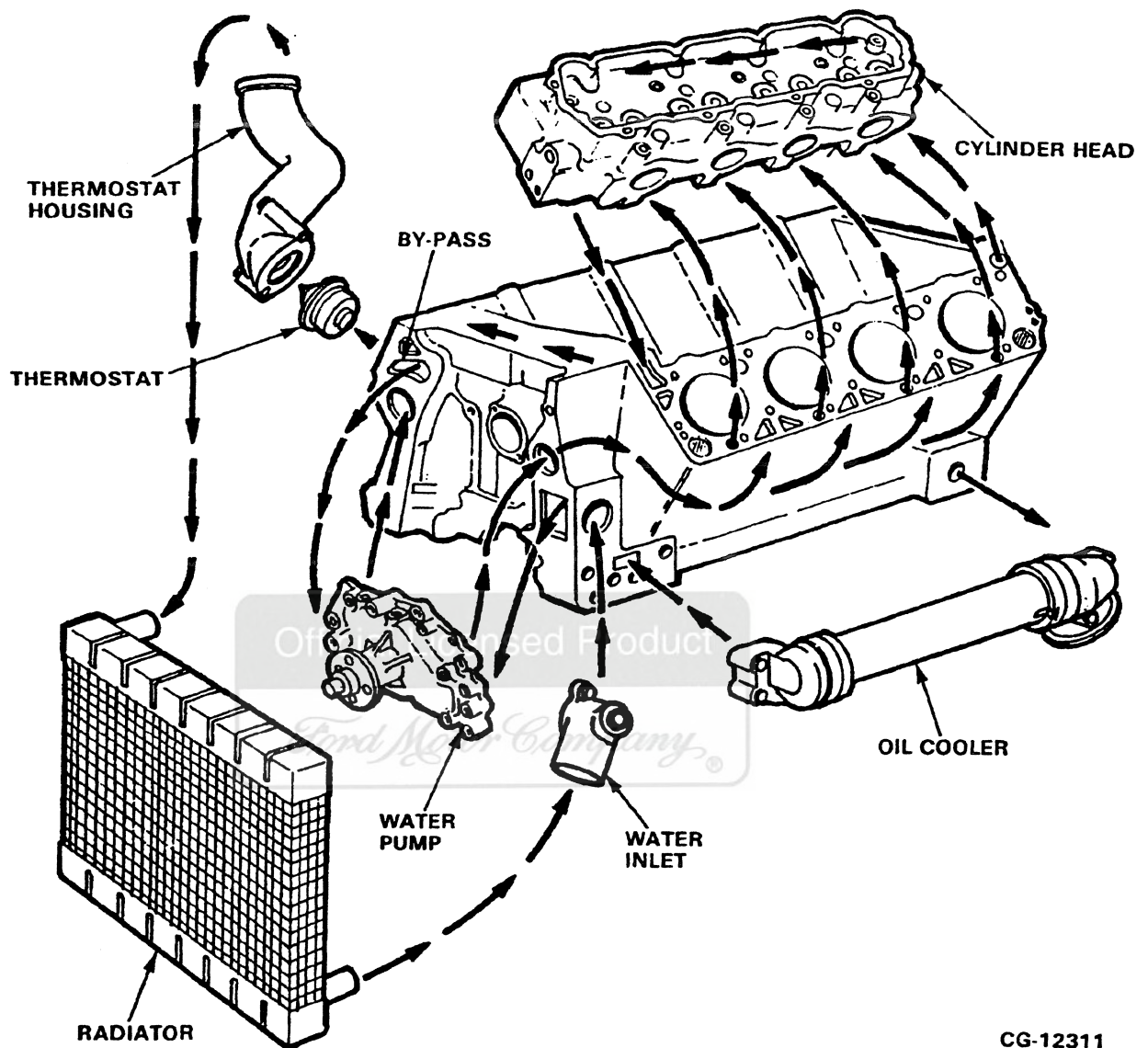


CG-15003

Figure 7B. Top View of 7.3 Liter Engine Major Component Location  
[1989 Model Year and Later]

## SERVICE MANUAL

### ENGINE SYSTEM



CG-12311

Figure 8. Coolant Flow

#### ENGINE COOLANT FLOW

Coolant flows from the radiator to the water pump and on through the engine to the engine temperature control thermostat.

When the thermostat is closed, coolant runs through a bypass back to the water pump without going through the radiator. This provides for rapid engine warm-ups. When the coolant

reaches 192°F (89°C) the thermostat starts to open and the coolant begins to flow to the radiator. The thermostat is fully open at 212°F (100°C).

**NOTE:** Refer to Figures 3A & B – 7A & B in the Introductory Section for heater supply and return locations, coolant drain locations and coolant related sensors.



# SERVICE MANUAL

## ENGINE SYSTEM

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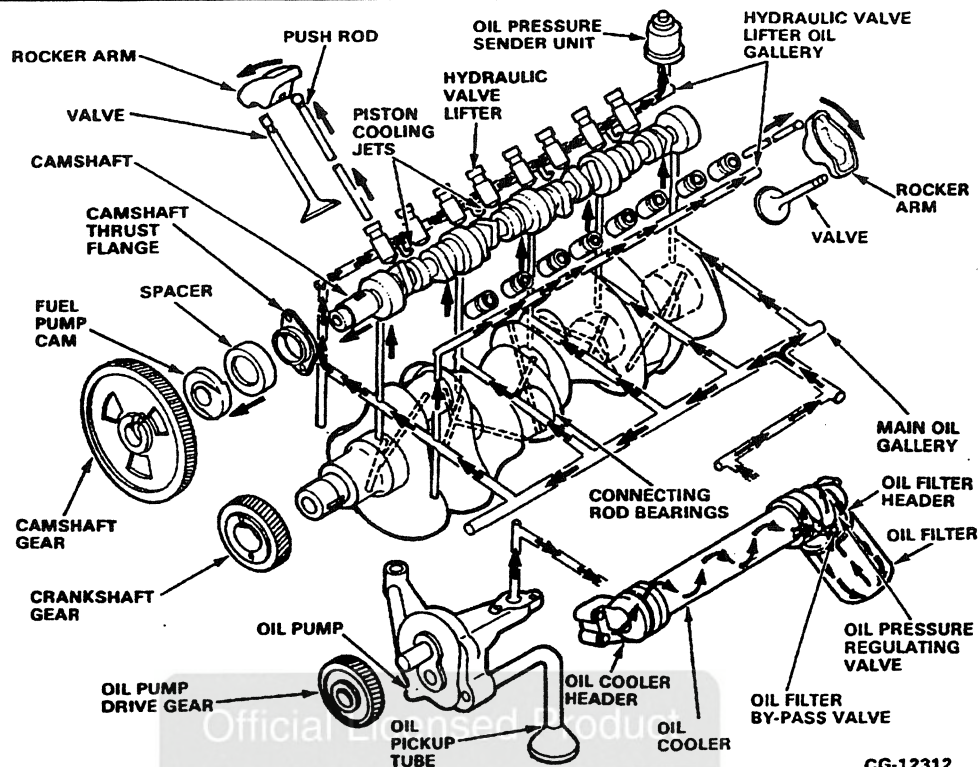


Figure 9. Lubrication Schematic

CG-12312

### LUBRICATION SYSTEM

Lube oil is drawn from the oil pan through an oil pickup screen and tube to the oil pump. The oil then goes through the oil cooler and flows around the outside of the heat exchange tubes (cooler bundle), rearward to the oil filter header. At the oil filter header the oil meets the pressure regulator valve.

#### Oil Pressure Regulator Valve

**NOTE:** The oil pressure regulator valve controls the volume and pressure of the filtered oil supplied to the engine. The volume of oil supplied by the oil pump is in excess of what is needed to lubricate the engine. Excess unfiltered oil is returned to the sump by the pressure regulator valve, keeping lube oil pressure within specified limits.

The oil filter header also has a by-pass valve which will open if the oil filter should become clogged.

#### By-Pass Valve

**NOTE:** However, if lube oil filter is not changed every 6000 miles (9656 km), 200 hours or 2 months (whichever comes first), filter contamination will cause a pressure drop due to high restriction. When such contamination occurs, the bypass valve will open and lube oil will "bypass" the filter to be distributed to the engine.

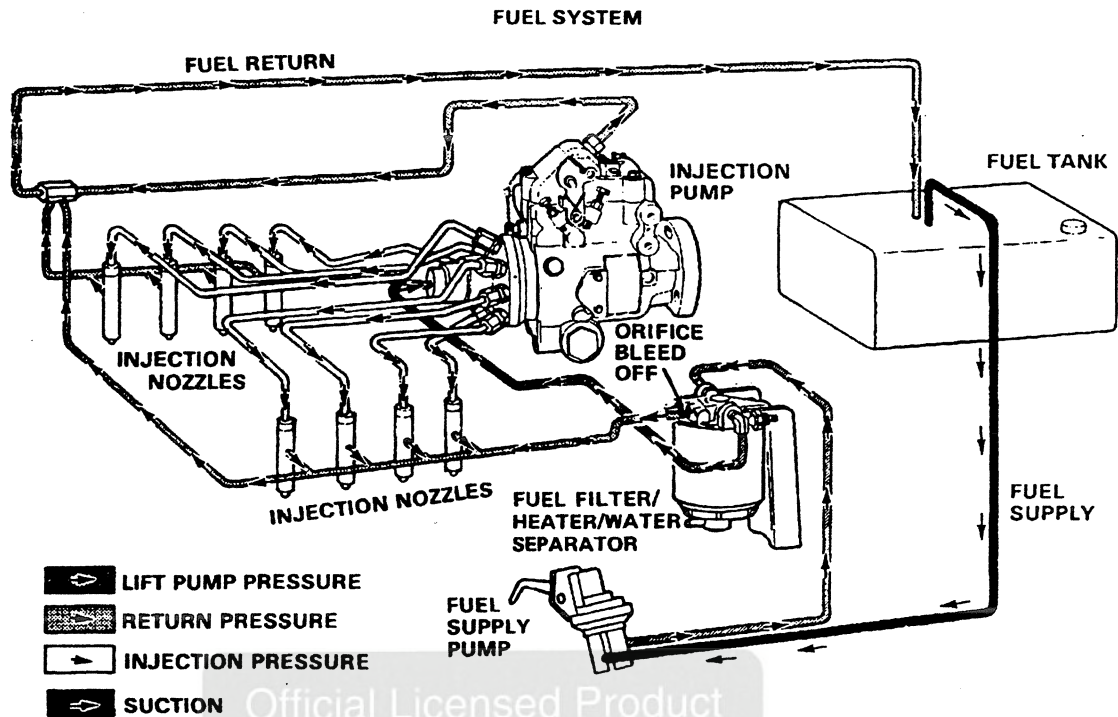
Under normal conditions, lube oil flows through the oil filter element and oil pressure regulator valve (on the clean side).

Five cross passages distribute filtered oil to vertical passages which feed the crankshaft main bearings, camshaft bearings and two tappet galleries. The piston cooling jets are fed from the same passage as the hydraulic roller cam followers.

The connecting rod bearings are fed from the main bearings via drilled passages in the crankshaft. The timing gears are lubricated by oil splash. Oil passes through the hydraulic tappet rollers and up the hollow pushrods to lubricate the rocker arm assemblies and valve stems.

# SERVICE MANUAL

## ENGINE SYSTEM



CG-11974

Figure 10A. Fuel Flow Schematic  
[U-Haul Applications Only]

### FUEL SYSTEM

#### [U-HAUL Applications Only]

Fuel from the tank is routed to the fuel supply pump which pumps fuel through a combination fuel filter, heater and water separator. The filter header contains a continuous vent (orifice bleed off system) which aids starting by eliminating the need to manually prime the fuel filter. A vacuum switch is incorporated into the fuel filter header indicating the need for filter replacement. The water separator portion of the filter assembly has a probe which will activate a instrument panel light when the filter requires draining at the water and sediment drain located on the bottom of the assembly.

**NOTE:** Properly filtered diesel fuel cannot be overemphasized. It is essential for long component life and reliability.

#### IMPORTANT

**DO NOT USE SUBSTITUTE FUEL FILTER ELEMENTS. USE ONLY AN APPROVED INTERNATIONAL® FILTER. REFER TO THE PARTS CATALOG WHEN ORDERING.**

Fuel enters the inlet of the injection pump and is delivered under high pressure through injection nozzles into the engine cylinders for combustion.

On each nozzle is a fuel return fitting that returns excess fuel to the fuel tank. Excess fuel from the injection pump and each injection nozzle is collected in bleed off lines and returned to the fuel tank.

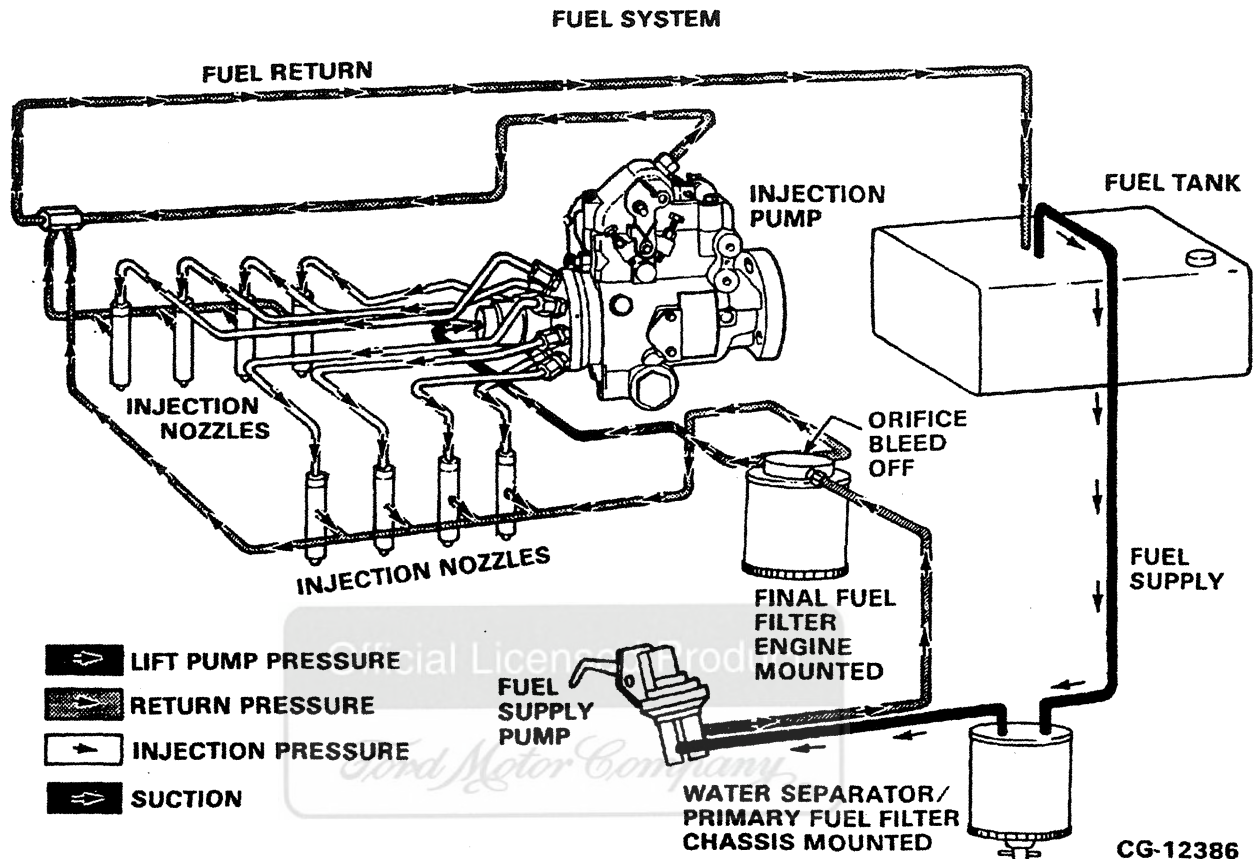
Injection nozzles are located on the inboard side of the cylinder head. This configuration has the following advantages:

- Injection nozzles operate in a cooler environment far removed from the exhaust manifold and exhaust ports.
- Injection lines do NOT interfere with engine accessories and provide better access to the engine for servicing.

# SERVICE MANUAL

## ENGINE SYSTEM

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**Figure 10B. Fuel Flow Schematic**  
[All Except U-Haul Applications]

### FUEL SYSTEM

[All Except U-Haul Applications]

Fuel from the tank is routed to the fuel supply pump through a primary filter/water separator.

Fuel then passes through the final fuel filter, which contains an orifice bleed off system which aids dry starting by eliminating the need to manually prime the fuel filter.

**NOTE:** Properly filtered diesel fuel cannot be overemphasized. It is essential for long component life and reliability.

Fuel enters the inlet of the injection pump and is delivered under high pressure through injection nozzles into the engine cylinders for combustion.

On each nozzle is a fuel return fitting that returns excess fuel to the fuel tank. Excess fuel from the injection pump and each injection nozzle are collected in bleed off lines and returned to the fuel tank.

Injection nozzles are located on the inboard side of the cylinder head. This configuration has the following advantages:

- Injection nozzles operate in a cooler environment far removed from the exhaust manifold and exhaust ports.
- Injection lines do **NOT** interfere with engine accessories and provide better access to the engine for servicing.

## SERVICE MANUAL

### ENGINE SYSTEM

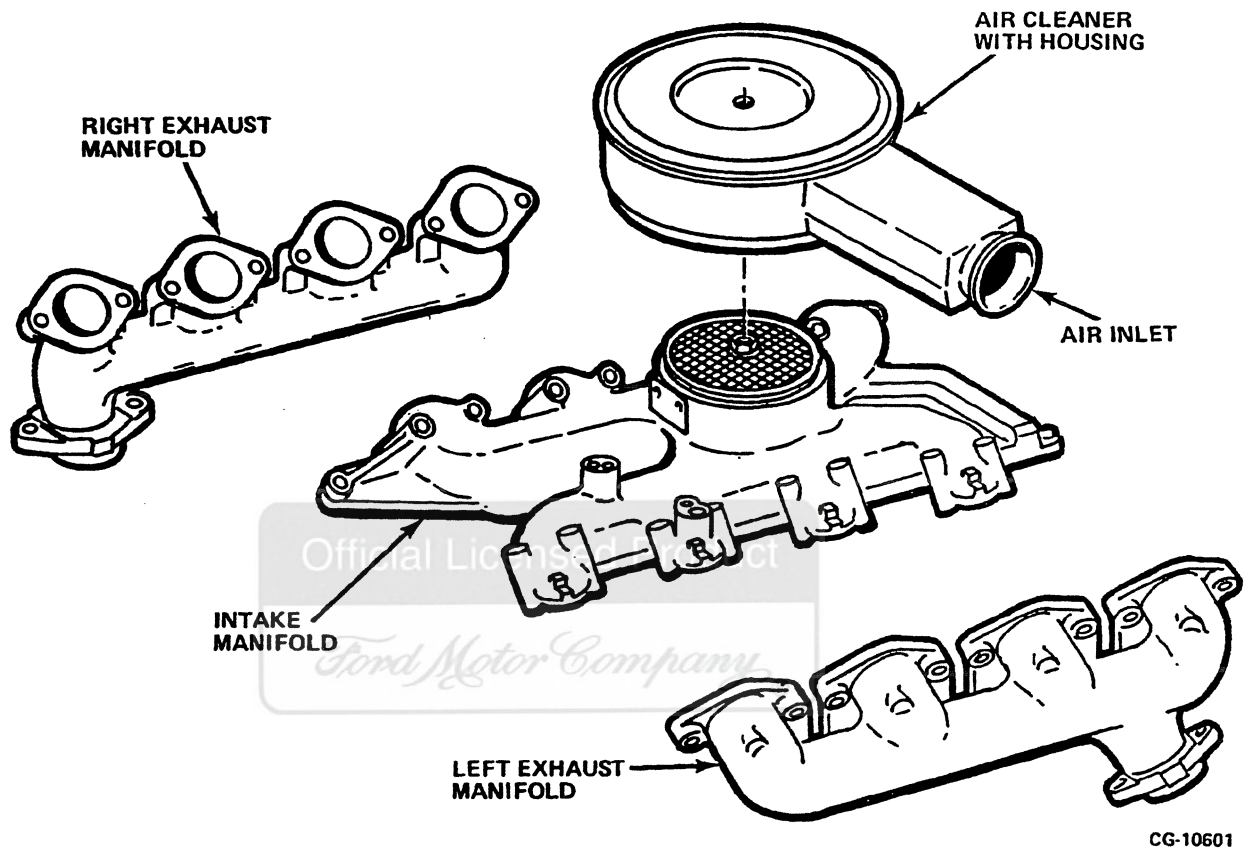


Figure 11. Air Intake and Exhaust Manifolds

#### AIR INDUCTION AND EXHAUST SYSTEMS

##### Description

The intake and exhaust systems consist of those components that convey filtered air to the engine cylinders and the exhaust gases to the atmosphere. The intake system includes an air cleaner, a one piece cast aluminum intake manifold and intake valves. The exhaust system includes two cast iron exhaust manifolds, muffler and exhaust piping.

##### Air Flow and Emission Control

Fresh filtered air is inducted through the intake system into the combustion chamber where it is compressed. When the air in the combustion chamber reaches the proper temperature and pressure, a metered amount of fuel is sprayed into the chamber where it burns producing power and exhaust gases. The resulting exhaust gases leave the cylinders through exhaust ports and exhaust manifolds to the mufflers and exhaust piping.



# SERVICE MANUAL

## ENGINE SYSTEM

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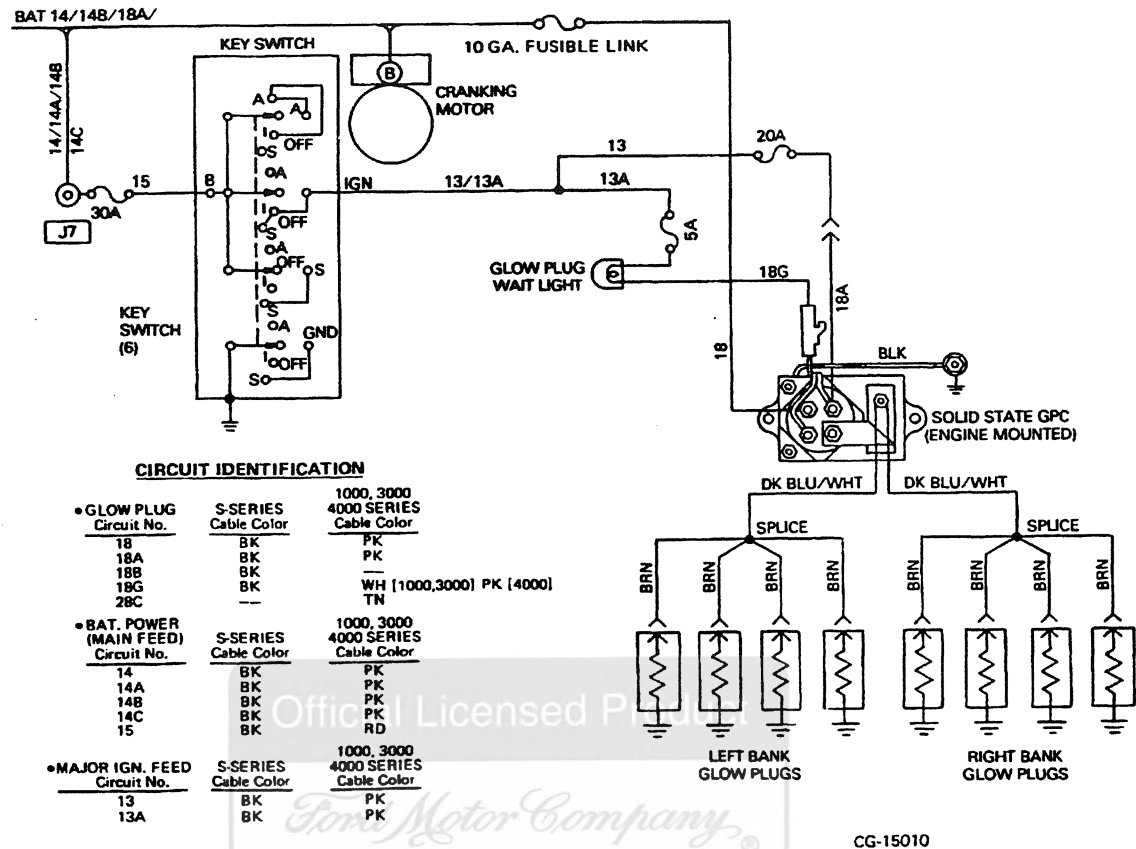


Figure 12. Solid State Glow Plug Wiring Diagram

### SOLID STATE GLOW PLUG SYSTEM

The 7.3 Liter Diesel Engine is equipped with a "solid state" glow plug system. The "solid state" system consists of a glow plug controller assembly, glow plug harness assembly and positive temperature coefficient (PTC) glow plugs.

The "solid state" system determines the glow plug temperature by electronically measuring the resistance of the glow plugs and maintains the temperature regardless of ambient conditions. The system is actuated when the ignition switch is turned on. A "wait to start" light indicates when the glow plugs have reached proper temperature by going out. An after glow operation of the glow plugs continues after the "wait to start" light has been turned off. This cyclic operation of the glow plugs provides for reduced white start up smoke. The after glow can be determined by listening to the relay operation.

A special feature of the "solid state" glow plug system is its instant recycling ability. If the switch is turned off, the operator can immediately recycle the system by turning the ignition switch on which will start the reheat cycle of the glow plugs and the "wait to start" light will come on. Engine cranking can begin as soon as the "wait to start" light goes out.

The power relay is mounted above the controller which contains the circuit board and the entire unit is covered by a plastic protective cover. The cover prevents accidental contact of the large resistor or relay parts during the operation of the system. If batteries are low, jump starting must be accomplished by connecting to the normal battery terminals, not the power relay.

### IMPORTANT

**DO NOT JUMP START BY CONNECTING POWER LEADS TO THE CONTROLLER MOUNTED RELAY. DOING SO WILL RESULT IN GLOW PLUG FAILURE.**

**SERVICE MANUAL**  
Official **MOUNTING ENGINE ON STAND**

---

**SECTION 1 INDEX**  
*Ford Motor Company*

**Page**

**MOUNTING ENGINE ON STAND ..... 1**

# SERVICE MANUAL

## MOUNTING ENGINE ON STAND

Section 1  
Page 1

### MOUNTING ENGINE ON STAND

#### STEP ONE...

Remove right side exhaust manifold and oil level gauge tube assembly. [Refer to **Figure 1.1**]

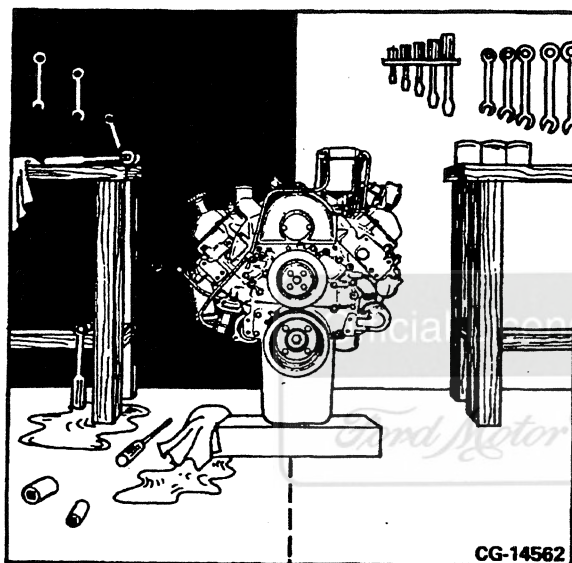


Figure 1.1. Component Removal for Mounting Engine on Stand

#### STEP TWO...

Use a safety catch on the hoist hook [Figure 1.2] when lifting engine.

#### WARNING

ASSURE THAT HOIST HOOK LIFTING BRACKET IS SECURELY INSTALLED AT ENGINE LIFTING EYES BEFORE LIFTING THE ENGINE.



CG-6033

Figure 1.2. Safety Catch

#### STEP THREE...

Install engine stand mounting adapter plate ZTSE-4151 using hardware provided at mounting holes in crankcase. [Refer to Figure 1.3]

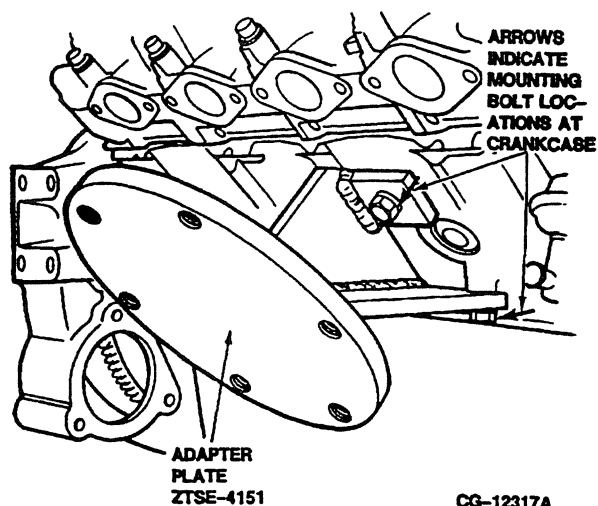


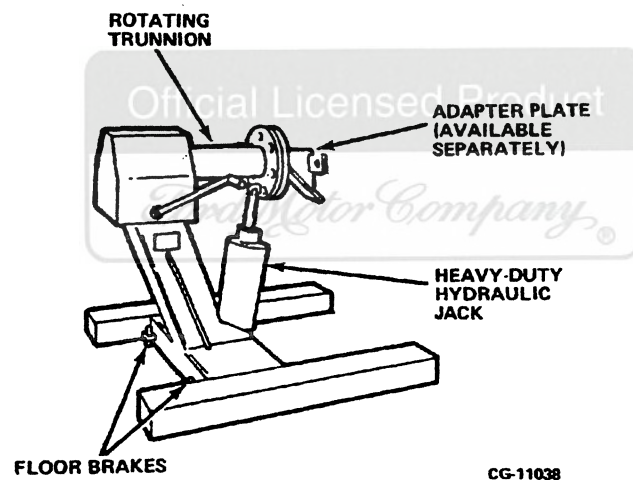
Figure 1.3. ZTSE-4151 Adapter Plate Installed on Engine

## SERVICE MANUAL MOUNTING ENGINE ON STAND

### MOUNTING ENGINE ON STAND - Continued

#### STEP FOUR...

Mount the engine onto the engine stand using specified adapter plate ZTSE-4151. [Refer to Figure 1.4]



CG-11038

Figure 1.4. SE-4034 Engine Stand Shown

#### IMPORTANT

REFER TO INSTRUCTIONS INCLUDED WITH ENGINE MOUNTING STAND AND ADAPTER PLATES FOR SPECIFIC DIRECTIONS ON THEIR SAFE USE.



# SERVICE MANUAL

## MANIFOLDS

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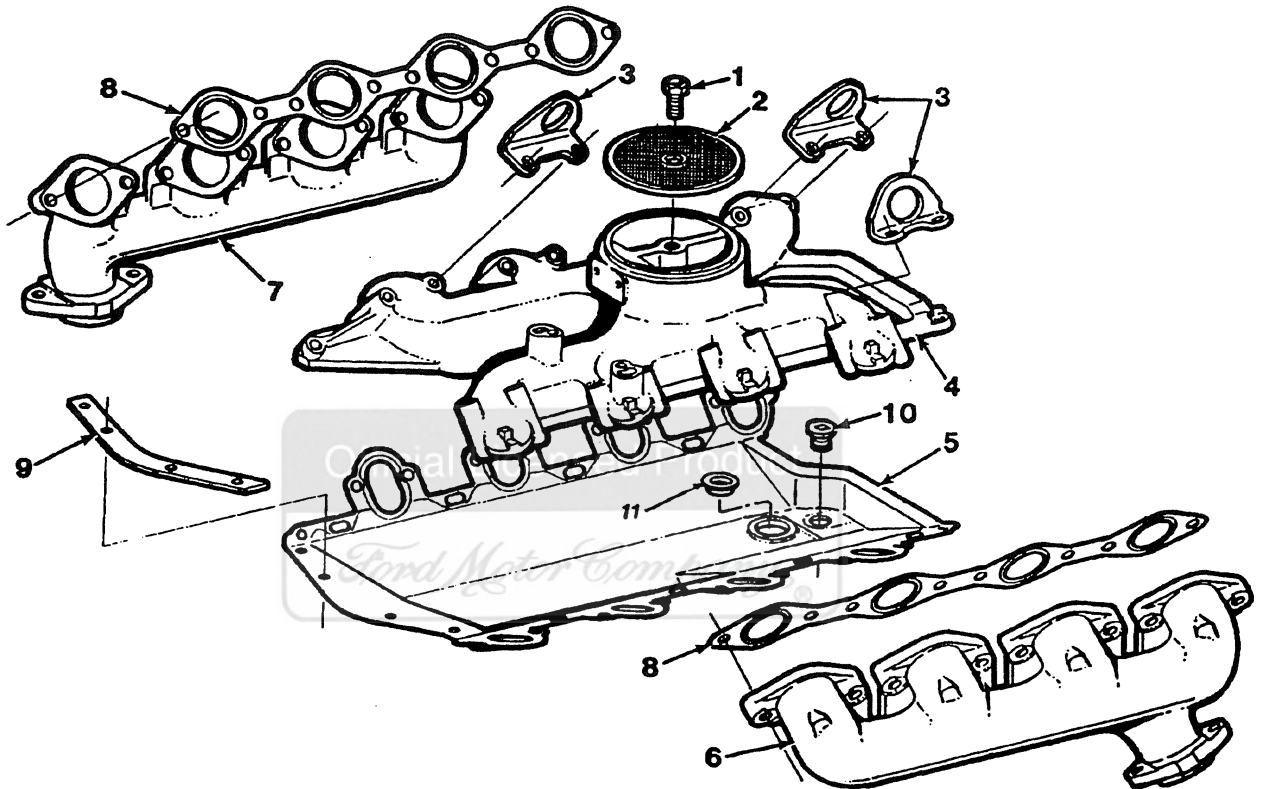
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# SERVICE MANUAL

## MANIFOLDS

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Page 1



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Figure 2.1. Intake and Exhaust Manifold Assembly (exploded view)

- |                          |                                |
|--------------------------|--------------------------------|
| 1. Stud                  | 7. R.H. Exhaust Manifold       |
| 2. Guard                 | 8. Exhaust Manifold Gasket (2) |
| 3. Lifting Bracket (3)   | 9. Valley Pan Strap            |
| 4. Intake Manifold       | 10. Valley Pan Drain Plug      |
| 5. Valley Pan and Gasket | 11. Closing Plug               |
| 6. L.H. Exhaust Manifold |                                |

( ) Denotes quantity.

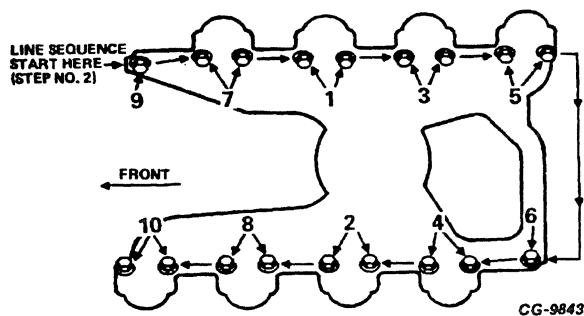
# SERVICE MANUAL MANIFOLDS

## SPECIFICATIONS

- No Manifold Service Specifications.

## SPECIAL TORQUES

- Intake Manifold Torque:



**NOTE:** For ease of installation start corner bolts No. 9 and No. 6 by hand prior to performing Steps 1 and 2.

STEP 1. Tighten bolts to 24 lbf-ft. (33N.m), in numbered sequence shown. (Figure 2.2).

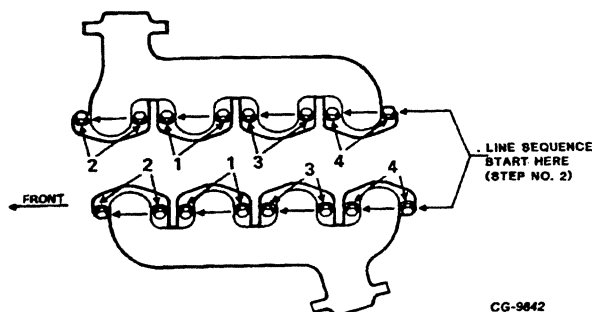
STEP 2. Tighten bolts to 24 lbf-ft. (33N.m), in line sequence shown. (Figure 2.2).

Official Licensed Product

Figure 2.2. Intake Manifold Bolt Torque Sequence

*Ford Motor Company*

- Exhaust Manifold Torque:\*



STEP 1. Tighten bolts to 35 lbf-ft. (47 N.m), in numbered sequence. (Figure 2.3).

STEP 2. Tighten bolts to 35 lbf-ft. (47 N.m), in line sequence shown. (Figure 2.3).

Figure 2.3. Exhaust Manifold Bolt Torque Sequence

Air Cleaner Stud Adapter**	45 lbf-ft. (61 N.m)
Intake Manifold Gasket (Valley Pan) Drain Plug	40 lbf-ft. (54 N.m)

\*Apply "Never-Seez" compound (P/N 634 227 C1) to bolt threads prior to assembly.

\*\*Apply general purpose "Lock N' Seal" (P/N 577 588 C1) to all bolt threads prior to assembly.

## SPECIAL SERVICE TOOLS

Tool No.	Description
ZTSE-4135	Fuel System Protector Cap Set
ZTSE-4136	Manifold Protector Cap

# SERVICE MANUAL

## MANIFOLDS

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Page 3

### EXHAUST MANIFOLDS

#### ■ REMOVAL

1. Left Exhaust Manifold – Remove eight prevailing torque bolts and hardened washers, Figure 2.4. Remove the manifold and gasket.

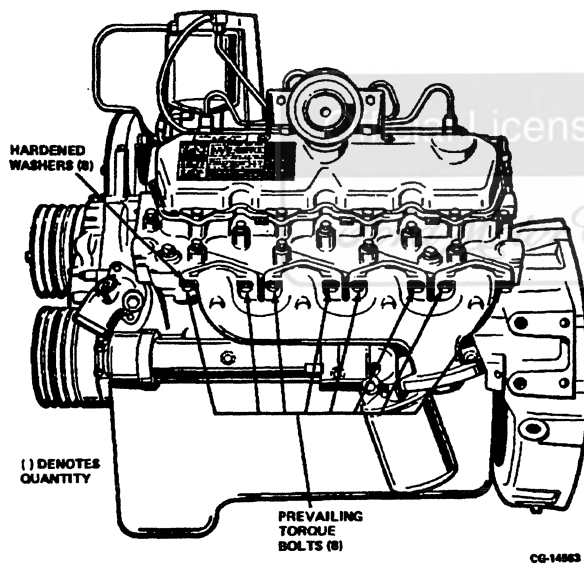


Figure 2.4. Removal – Left Exhaust Manifold

2. Prior to removal of right exhaust manifold, remove the oil level gauge assembly as follows:

a. Loosen the nut and washer from the stud bolt, to free the oil level gauge tube bracket. Refer to Figure 2.5.

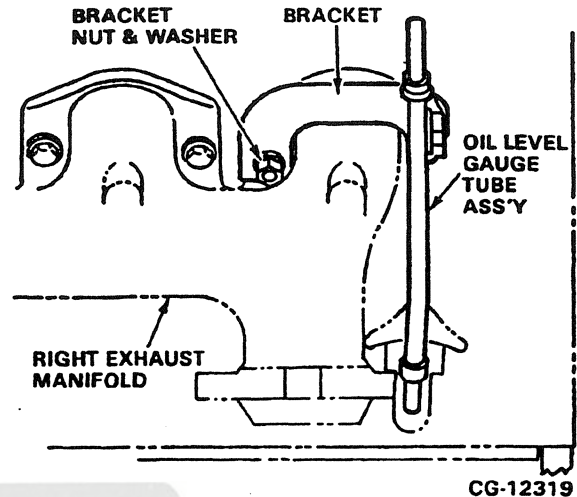


Figure 2.5. Loosen Oil Level Gauge Bracket

b. Remove the oil level gauge tube assembly (with bracket) from the crankcase. Refer to Figure 2.6

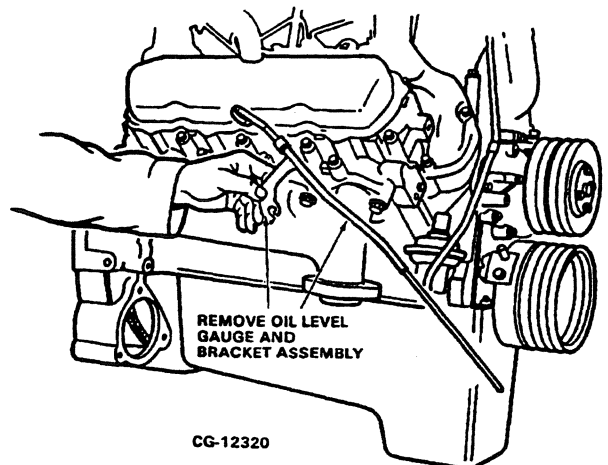


Figure 2.6. Remove Oil Level Gauge Assembly

## SERVICE MANUAL MANIFOLDS

### EXHAUST MANIFOLDS - Continued

#### ■ REMOVAL - Continued

3. Right Exhaust Manifold - Remove the seven prevailing torque bolts, one prevailing torque stud bolt and eight hardened washers. Refer to Figure 2.7.

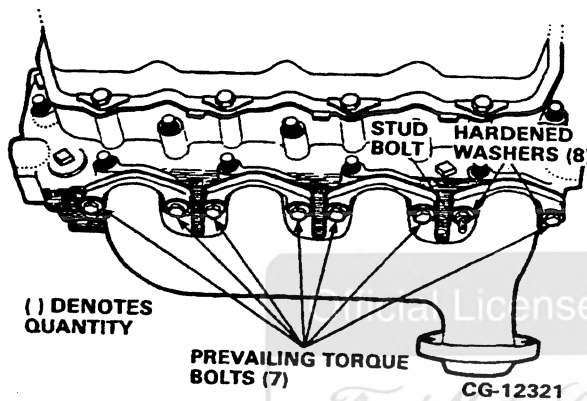


Figure 2.7. Removal - Right Exhaust Manifold

#### ■ CLEANING

1. Exhaust manifolds are cast in one piece and must be thoroughly cleaned with a suitable non-caustic solvent. After cleaning blow dry using filtered compressed air.

#### ■ INSPECTION

1. Visually inspect the clean exhaust manifolds for cracks.
2. Replace if cracked or if exhaust leakage is excessive.

#### ■ INSTALLATION

1. Install the right and left exhaust manifolds using new gaskets as follows:

### IMPORTANT

WHEN INSTALLING THE EXHAUST MANIFOLDS, ONLY USE METAL PREVAILING TORQUE BOLTS (WITH INTERFERENCE THREAD) AND HARDENED WASHERS.

- a. Apply "NEVER-SEEZ" to the bolts.
- b. Left exhaust manifold; install using eight mounting bolts with hardened washers.
- c. Right exhaust manifold; install seven mounting bolts, one bolt stud and eight hardened washers.
- d. Tighten bolts, in steps, to proper torque as specified under "Special Torques" in this section.

### INTAKE MANIFOLD

#### ■ REMOVAL

Remove the following:

Refer to the appropriate manual section for removal of these components.

- Fuel Filter Assembly
- Fuel Return Lines (Low Pressure)
- Fuel Injection Pump w/High Pressure Lines
- Glow Plug Harness and Controller
- CDR Assembly
- Air Cleaner (See NOTE)

**NOTE:** After air cleaner removal, install Intake Manifold Cover ZTSE-4136.

### IMPORTANT

WHEN REMOVING FUEL LINES, THE LINES SHOULD HAVE DUST CAPS INSTALLED OVER ENDS AS WELL AS THE FITTINGS WHERE THE LINES WERE REMOVED. THIS PROCEDURE IS TO PROTECT AGAINST ENTRY OF FOREIGN MATTER IN THE FUEL SYSTEM. USE FUEL SYSTEM PROTECTOR CAP SET ZTSE-4135.

# SERVICE MANUAL

## MANIFOLDS

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### INTAKE MANIFOLD – Continued

#### ■ REMOVAL – Continued

1. Remove eighteen intake manifold mounting bolts and three lifting eyes, Figure 2.8.

**NOTE:** Keep bolts and lifting eyes together for reinstallation in the same locations. One lifting eye will have been removed when the CDR valve assembly was removed to access the intake manifold.

2. Remove the intake manifold from the engine to expose the valley pan gasket.
3. Remove the valley pan drain plug and set aside. Refer to Figure 2.9.
4. Remove the four valley pan mounting bolts and washers, then remove the valley pan strap, Figure 2.10.
5. Remove valley pan and gasket assembly. Discard old valley pan, but retain the drain plug.

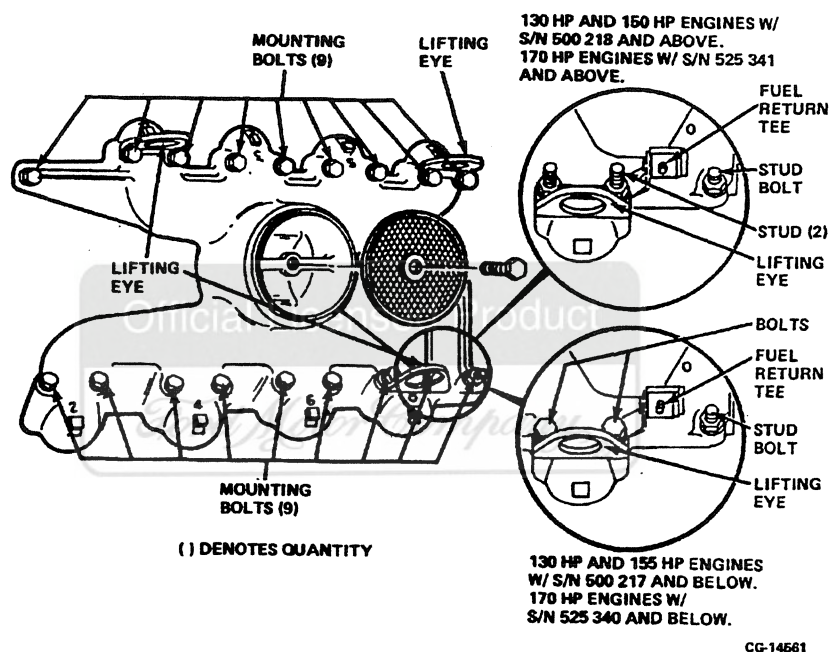


Figure 2.8. Intake Manifold Removal

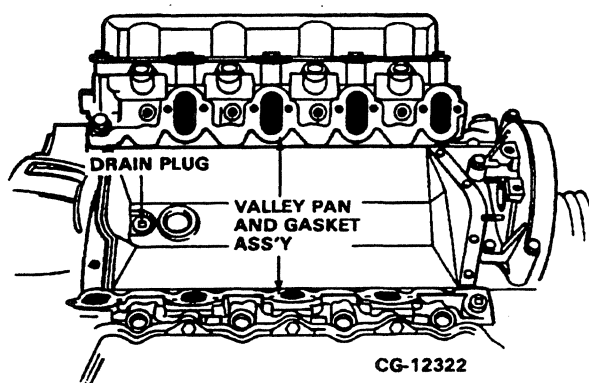


Figure 2.9. Remove Valley Pan Drain Plug

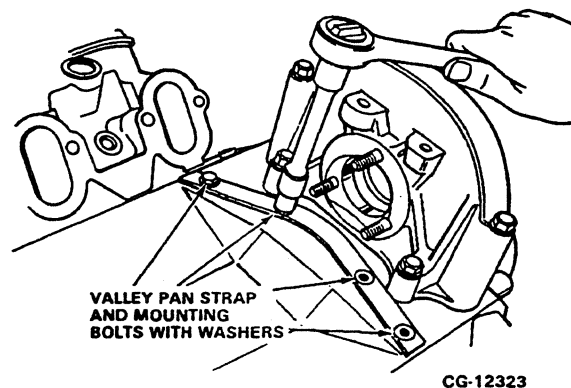


Figure 2.10. Remove Valley Pan Strap



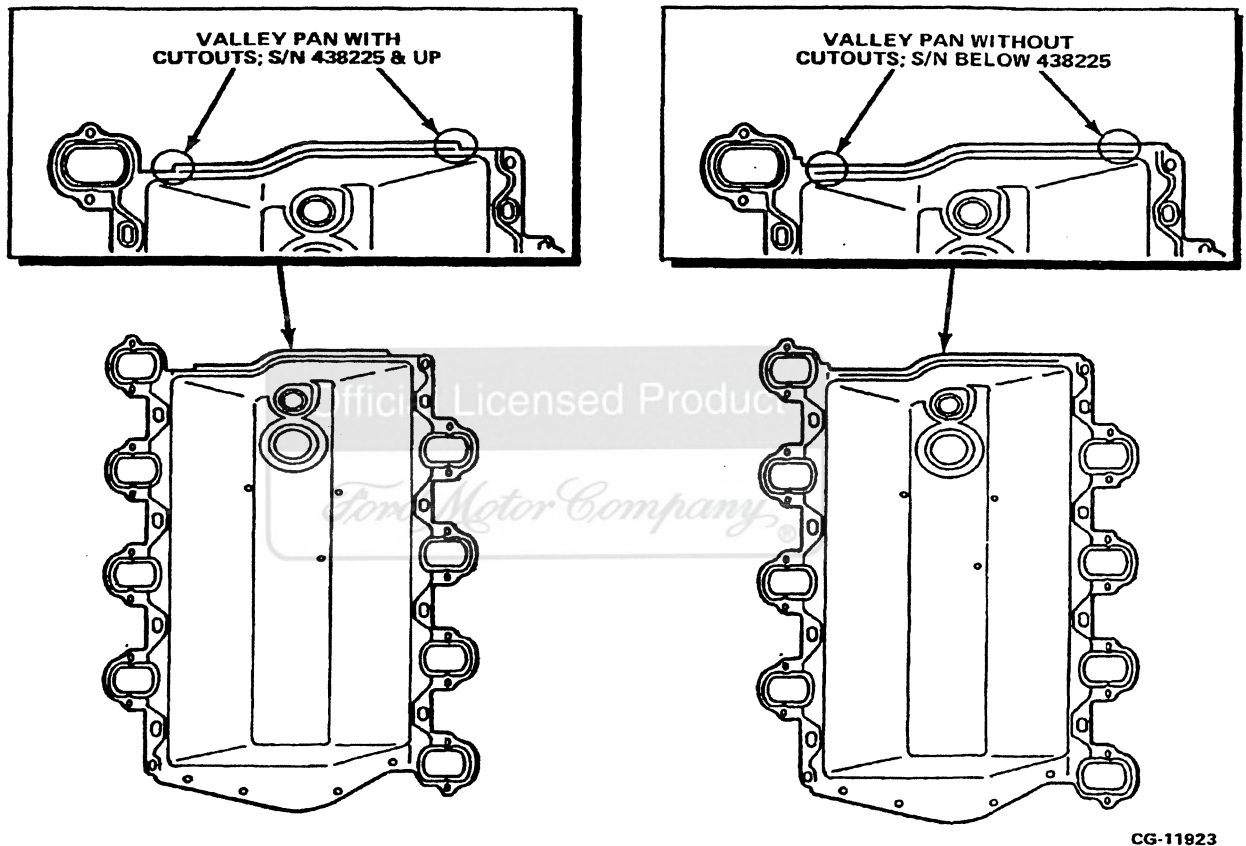
## SERVICE MANUAL

### MANIFOLDS

#### INTAKE MANIFOLD – Continued

##### ■ REMOVAL – Continued

NOTE: The valley pan and gasket assembly was revised to accept a larger amount of R.T.V. sealant by adding rear corner cutouts. Refer to **Figure 2.11**.



CG-11923

**Figure 2.11. Valley Pan and Gasket Assembly Comparison**

##### ■ CLEANING

1. Clean the aluminum intake manifold thoroughly, using a suitable non-caustic solvent.
2. Clean all old RTV and gasket material from the mating surfaces using "Parts Solvent Cleaner" (P/N 59007C1). The surface should be free of oil to enhance adhesion of the new R.T.V.
3. Dry using filtered compressed air, prior to inspection.

##### ■ INSPECTION

1. Visually inspect the intake manifold for cracks.
2. Place mounting surface (outlets) of manifold on a smooth flat surface and check for warpage.
3. Replace manifold if cracked or warped.

**NOTE:** Do not surface grind intake manifold to correct warpage. Any attempt to resurface intake manifold will create misalignment of ports to cylinder heads.

# SERVICE MANUAL

## MANIFOLDS

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### INTAKE MANIFOLD – Continued

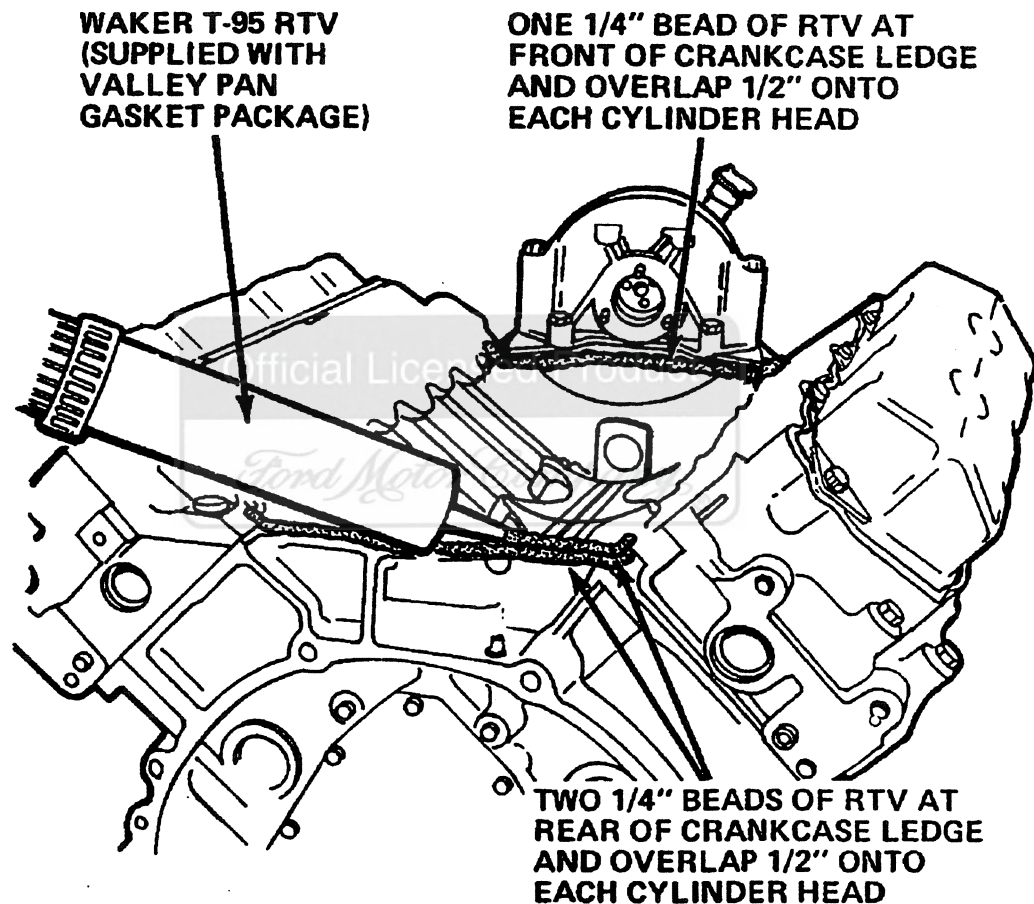
#### ■ INSTALLATION

1. Apply a 1/4" bead of Waker T-95 RTV [included with Valley Pan Gasket package] at the front of the crankcase and overlap 1/2" onto each cylinder head, as shown in Figure 2.12.

2. Apply two 1/4" beads of Waker T-95 RTV at the rear of the crankcase and overlap 1/2" onto each cylinder head, as shown in Figure 2.12.

#### IMPORTANT

AFTER APPLICATION OF R.T.V. SEALANT, COMPLETE ASSEMBLY OF THE VALLEY PAN, STRAPS AND INTAKE MANIFOLD WITHIN 15 MINUTES.



CG-14748

Figure 2.12. R.T.V. Sealant Application for Valley Pan Installation

3. Coat the bottom of the valley pan gasket [side facing cylinder head only] at the sealing area for water ports with Loctite 515 Gasket Eliminator provided with the valley pan gasket service package. Refer to Figure 2.13.

NOTE: 1989 Model Year and beyond have cup plugs in the coolant passages and DO NOT require Loctite 515 Gasket Eliminator.

#### IMPORTANT

FOLLOW THE DIRECTIONS ON THE LOCTITE 515 CONTAINER FOR PROPER APPLICATION PROCEDURES.

## SERVICE MANUAL MANIFOLDS

### INTAKE MANIFOLD – Continued

#### ■ INSTALLATION – Continued

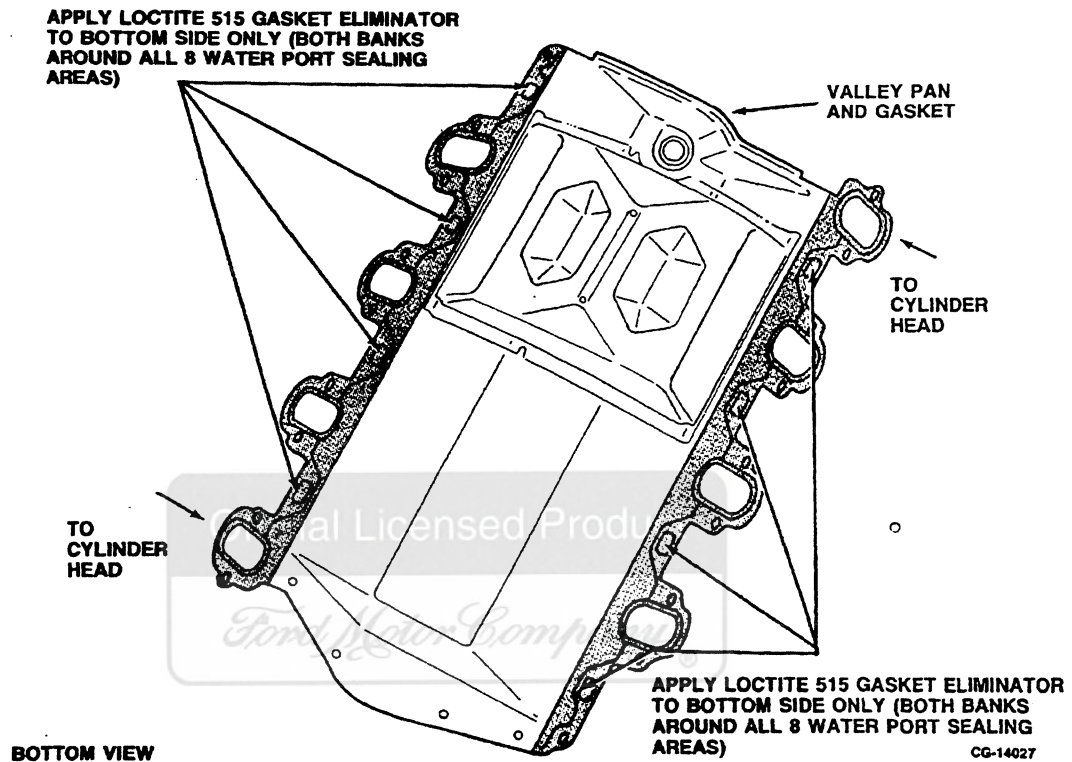


Figure 2.13. Apply Loctite 515 to Valley Pan Gasket Sealing Area Around Water Ports [1988 Model Year and Earlier]

4. Place the new valley pan gasket onto the crankcase. Install the valley pan strap and tighten the four bolts and washers to the standard torque. Refer to Figure 2.14.

#### IMPORTANT

DO **NOT** WIPE OFF EXCESS R.T.V. SEALANT FROM THE VALLEY PAN AFTER INSTALLATION. ALLOW THE R.T.V. TO OOZE AT THE MATING SURFACE. DO **NOT** ATTEMPT TO EVEN OUT THE RTV.

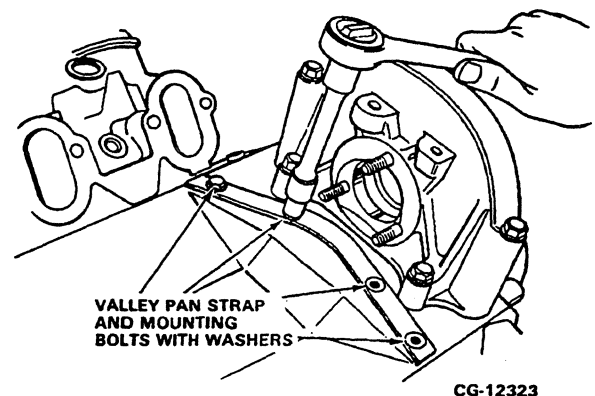


Figure 2.14. Install Valley Pan Strap

# SERVICE MANUAL

## MANIFOLDS

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### INTAKE MANIFOLD – Continued

#### ■ INSTALLATION – Continued

5. Apply an additional 1/4" bead of WAKER T-95 RTV to the valley pan cutouts at the rear of the pan. Refer to Figure 2.15.

6. Install the valley pan drain plug and tighten to the specified torque. Refer to "Special Torques" in this section or the Appendix. Refer to Figure 2.15.

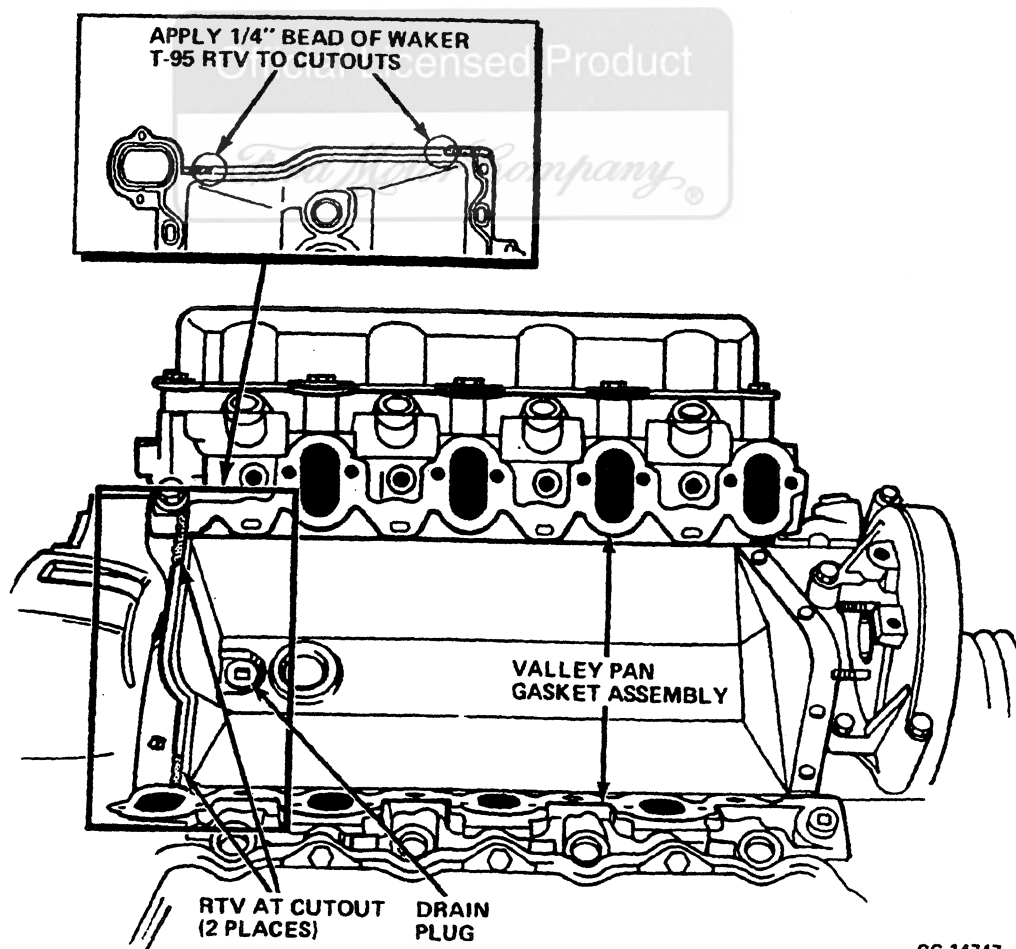
7. Install intake manifold. Install the eighteen intake manifold mounting bolts and three lifting eyes to their original positions. Refer to Figure 2.8 for lifting eye location.

8. Tighten mounting bolts as specified under "Special Torques" in this section.

9. Reinstall the following:

Refer to the appropriate manual section for installation procedures for these components.

- CDR Assembly
- Glow Plug Harness and Controller
- Fuel Injection Pump with High Pressure Lines
- Fuel Return Lines (Low Pressure)
- Fuel Filter Assembly
- Air Cleaner



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Figure 2.15. Valley Pan Drain Plug Location

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

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# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 1

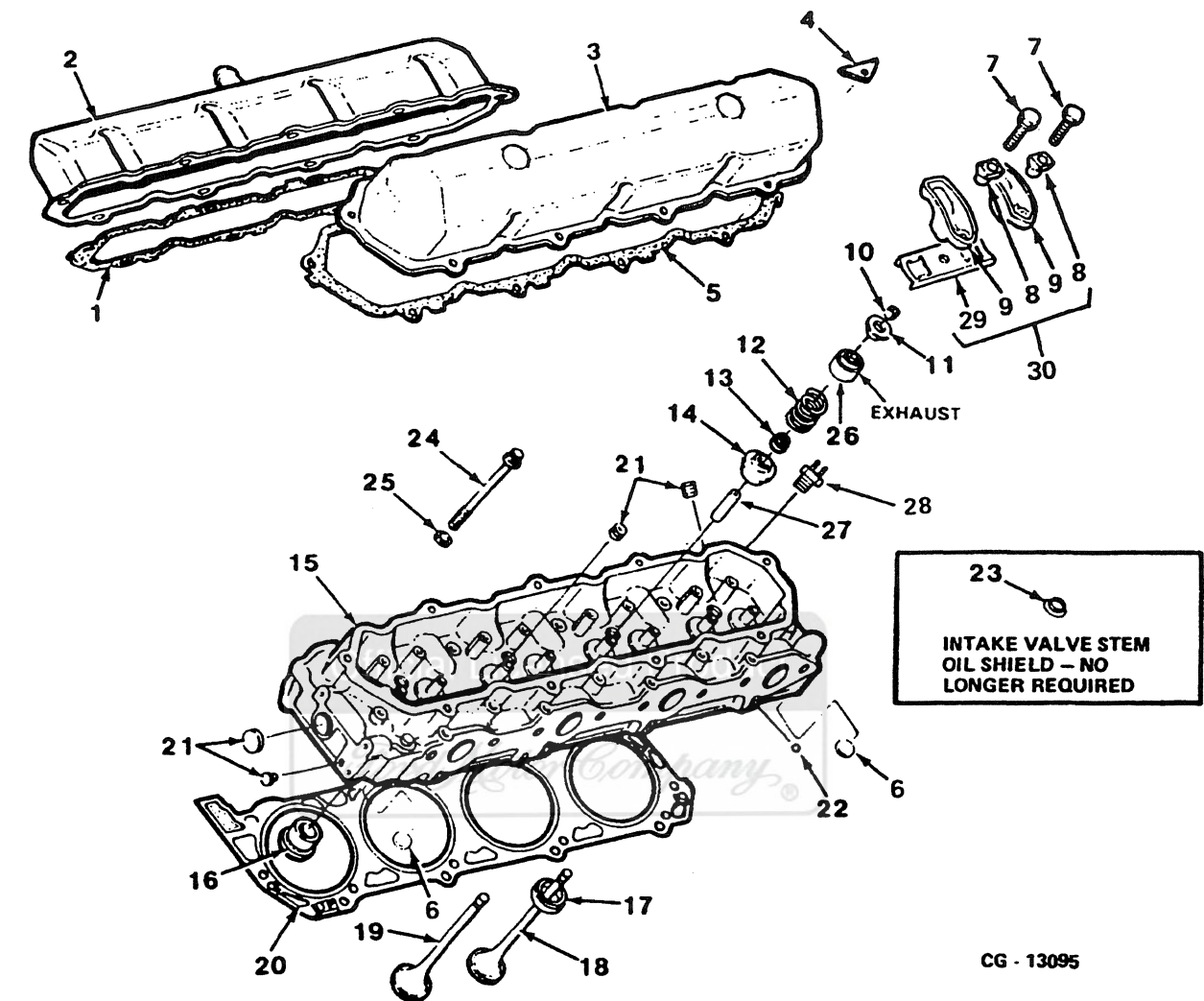


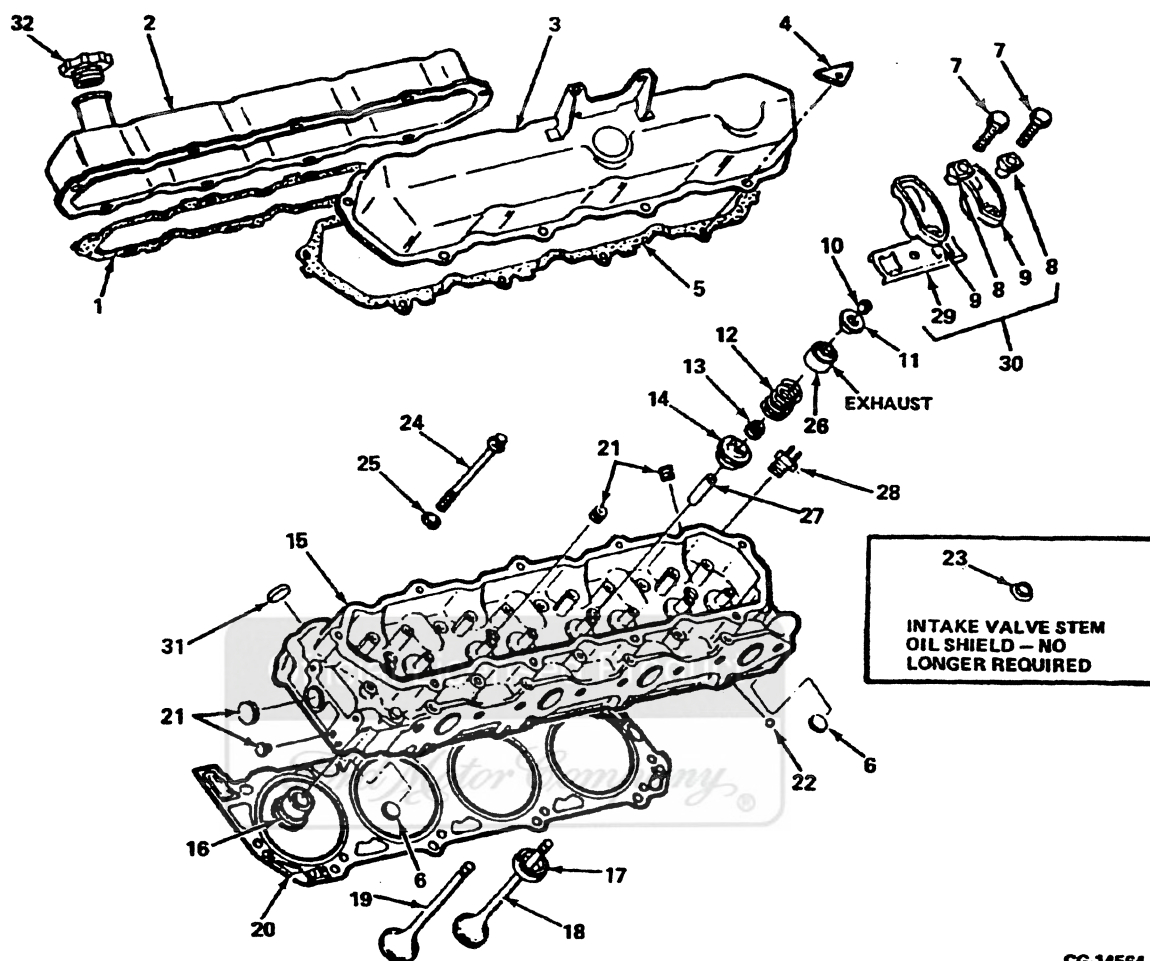
Figure 3.1A. Cylinder Head and Valves  
[1988 Model Year & Earlier]

- |                                  |                                   |   |
|----------------------------------|-----------------------------------|---|
| 1. Valve Cover Gasket            | 12. Valve Spring w/Damper         | 23. Oil Shield (Intake)(No Longer Req.) |
| 2. Valve Cover (RH Side)         | 13. Valve Stem Seal (Intake Only) | 24. Cylinder Head Bolt                  |
| 3. Valve Cover (LH Side)         | 14. Valve Rotator                 | 25. Washer                              |
| 4. Washer                        | 15. Cylinder Head                 | 26. Oil Shield (Exhaust)                |
| 5. Valve Cover Gasket            | 16. Combustion Chamber Insert     | 27. Valve Guide (Service Only)          |
| 6. Cup Plugs                     | 17. Exhaust Valve Seat            | 28. Temperature Switch, HPCA Control    |
| 7. Valve Lever Bolt and Washer † | 18. Exhaust Valve                 | 29. Valve Lever Post Retainer           |
| 8. Valve Lever Post              | 19. Intake Valve                  | 30. Valve Lever Assembly                |
| 9. Valve Lever                   | 20. Cylinder Head Gasket          |   |
| 10. Valve Spring Retainer Lock   | 21. Cup and Pipe Plugs            |   |
| 11. Valve Spring Retainer        | 22. Ball                          |   |

† Washer Not Shown

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES



CG-14564

Figure 3.1B. Cylinder Head and Valves  
[1989 Model Year & Later]

- |                                  |  |                                |
|----------------------------------|--|--------------------------------|
| 1. Valve Cover Gasket            | 13. Valve Stem Seal (Intake Only)        | 25. Washer (No Longer 15 Req.) |
| 2. Valve Cover (RH Side)         | 14. Valve Rotator                        | 26. Oil Shield (Exhaust)       |
| 3. Valve Cover (LH Side)         | 15. Cylinder Head                        | 27. Valve Guide (Service Only) |
| 4. Washer                        | 16. Combustion Chamber Insert            | 28. Temperature Switch         |
| 5. Valve Cover Gasket            | 17. Exhaust Valve Seat                   | 29. Valve Lever Post Retainer  |
| 6. Cup Plugs                     | 18. Exhaust Valve                        | 30. Valve Lever Assembly       |
| 7. Valve Lever Bolt and Washer † | 19. Intake Valve                         | 31. Cup Plug*                  |
| 8. Valve Lever Post              | 20. Cylinder Head Gasket                 | 32. Oil Cap                    |
| 9. Valve Lever                   | 21. Cup and Pipe Plugs                   |                                |
| 10. Valve Spring Retainer Lock   | 22. Ball                                 |                                |
| 11. Valve Spring Retainer        | 23. Oil Shield (Intake) (No Longer Req.) |                                |
| 12. Valve Spring w/Damper        | 24. Cylinder Head Bolt                   |                                |

† Washer Not Shown

\* Four 11/16in. cup plugs have been added to each cylinder head, which eliminates the need for the application of Loctite 515 gasket eliminator on the valley pan gasket. Refer to Section 2.

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 3

### SPECIFICATIONS

#### EXHAUST VALVES:

Stem Diameter	0.37165–0.37235 in. (9.4399–9.4577 mm)
Stem to Guide Clearance (Max. Allowable Before Replacement)	0.0055 in. (140 mm)
Face to Stem Run-Out (T.I.R. Max.)	0.0015 in. (0.0381 mm)
Valve Face Angle	37.5°
Valve Face Margin (Min.)	0.053" (1.35 mm)

#### INTAKE VALVES:

Stem Diameter	0.37165–0.37235 in. (9.4399–9.4577 mm)
Stem to Guide Clearance (Max. Allowable Before Replacement)	0.0055 in. (140 mm)
Face to Stem Run-Out (T.I.R. Max.)	0.0015 in. (0.0381 mm)
Valve Face Angle	30°
Valve Face Margin (Min.)	0.112 in. (2.84 mm)

#### CYLINDER HEADS:

Bore Diameter in Cylinder Head	
Valve Guide Insert (Service)	0.6234–0.6244 in. (15.834–15.859 mm)
Valve Guide O.D. (Service)	0.6248–0.6252 in. (15.87–15.88 mm)
Inside Diameter of Valve Guide Inserts (Service)	0.3736–0.3746 in. (9.489–9.514 mm)
Valve Guide Bore Finish (Micro inches)	63–93
Valve Guide Bore Run-Out	0.002 in. (0.05 mm)
Valve Guide Taper (Max.)	0.005 in. (0.127 mm)
Valve Guide Length (Service)	2.600 in. (66.04 mm)
Valve Seat Width (Int. & Exh.)	0.065–0.095 in. (1.651–2.413 mm)
Valve Seat Angle (Int.)	30°
Valve Seat Angle (Exh.)	37.5°
Valve Seat Run-Out (T.I.R. Max.)	0.002 in. (0.05 mm)
Valve Seat Insert O.D. (Exhaust Only)	1.6671–1.6681 in. (42.34–42.37 mm)
Valve Seat Insert I.D. (Exhaust Only)	1.366–1.376 in. (34.696–34.950 mm)
Valve Seat Insert Counterbore Diameter – Cylinder Head	1.6645–1.6655 in. (42.28–42.30 mm)
Gasket Surface Flatness	0.003 in. (0.0762 mm) in 6 inches.; 0.006 inches. (0.1524 mm) overall
Gasket Surface Finish (Micro inches)	63–125
Deck to Deck Dimension (Head Thickness Overall)	4.795–4.805 in. (121.793–122.047 mm)
Pre-Combustion Chamber Insert	
Recession/Protrusion	–0.0025 in./+0.0025 in. (–0.064 mm/+0.064 mm)

Valve Head Recession Relative to Deck (Head Gasket) Surface on Cylinder Head:

Intake	0.042–0.054 in. (1.06–1.37 mm)
Exhaust	0.051–0.063 in. (1.29–1.60 mm)

## SERVICE MANUAL CYLINDER HEAD AND VALVES

### SPECIFICATIONS – Continued

Valve Springs: [Serviced only as an assembly (P/N 317 365 C11)]

Valve Spring w/Damper

Free Length ..... 2.075"  $\pm$  .150" (52.705 mm  $\pm$  3.8 mm)

Test Length ..... 1.397" (35.48 mm)

Test Load ..... 200 lbs.  $\pm$  8 lbs.

### SPECIAL TORQUES

#### CYLINDER HEAD BOLT TORQUE:

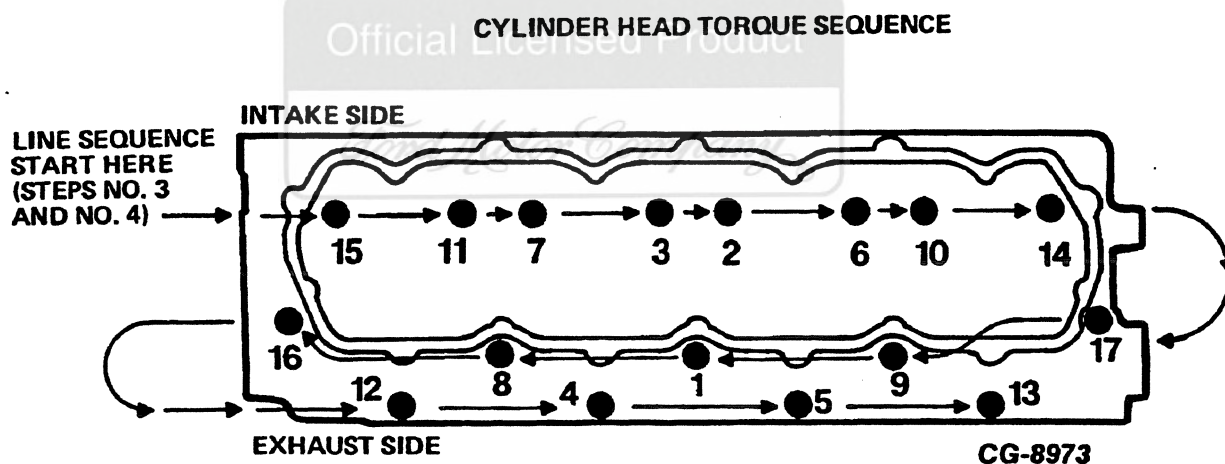


Figure 3.2. Cylinder Head Bolt Torque Sequence

#### HEAD BOLTS

STEP 1. 65 lbf-ft. (88 N.m)\*

STEP 2. 85 lbf-ft. (115 N.m)\*

STEP 3. 100 lbf-ft. (135 N.m)\*\*

STEP 4. Repeat Step #3

\*Tighten bolts in numbered sequence, Figure 3.2.

\*\*Tighten bolts in line sequence, Figure 3.2.

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
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### SPECIAL TORQUES - Continued

#### VALVE COVER BOLTS:

Install and tighten all bolts to 6 lbf.-ft. (8 N.m) in line sequence, Figure 3.3.

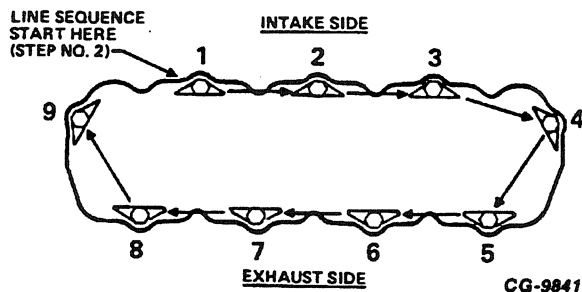


Figure 3.3. Valve Cover Torque Sequence

#### VALVE LEVER POST:

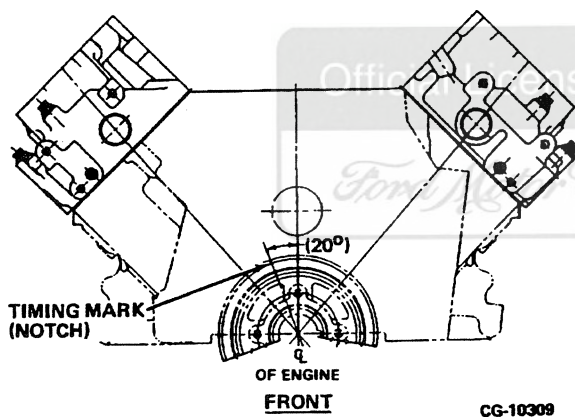


Figure 3.4. Engine Crankshaft Vibration Damper Timing Mark Positioned at 11:00 (20° from Vertical) for Valve Lever Post Bolt Torque (Damper Behind Pulley)

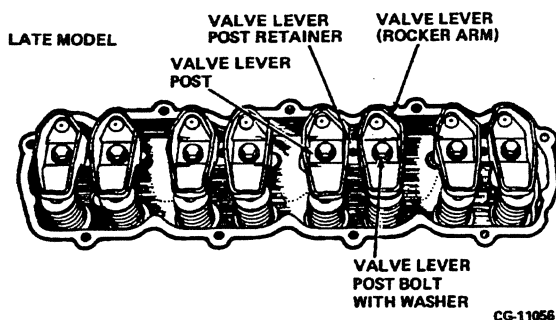


Figure 3.5. Valve Lever (Rocker Arm) Assembly

#### IMPORTANT

**STEP 1** - Rotate engine until timing mark (notch) on vibration damper is at 11:00 (20° before vertical). This positions all pistons below TDC so the valves do not contact the pistons when tightening the valve lever assemblies.

**STEP 2** - Tighten each pair of valve lever post bolts down **EVENLY** to 20 lbf.-ft. (27 N.m).

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

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#### SPECIAL SERVICE TOOLS

<u>Tool No.</u>	<u>Description</u>
ZTSE-1631-A	Valve Seat Cutter (Less Stones & Pilot)
ZTSE-1631-69	Valve Seat Grinding Set
SE-1896	Cylinder Head Lifting Sling
ZTSE-1951-B and ZTSE-1951-21	Exhaust Valve Seat Remover
ZTSE-2241	Valve Spring Tester
ZTSE-1846 or ZTSE-4137†	Valve Spring Compressor
ZTSE-4138	Valve Stem Seal Installer
ZTSE-4157	Valve Guide Service Tools
ZTSE-4135	Fuel System Protector Cap Set
ZTSE-4141	Nozzle Holder Rack
ZTSE-4164	Exhaust Valve Seat Installer
ZTSE-4155A	Expansion Plug Replacer
SE-2506	Valve Guide Bore Gauge

Official Licensed Product

*Ford Motor Company*®

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† ZTSE-4137 is used for servicing the valve train with the cylinder head installed.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

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### CYLINDER HEAD (Removal & Reassembly)

#### ■ Removal

Remove the following:

- Fuel Filter Assy.
- Fuel Return Lines (Low Pressure)
- Injection Pump (w/High Pressure Lines)
- CDR Assy.
- Glow Plug Controller
- Glow Plug Harness
- Glow Plugs
- Exhaust Manifolds
- Intake Manifold
- Valley Pan and Gasket
- Oil Level Gauge Assy.

Refer to the appropriate manual section for removal procedures.

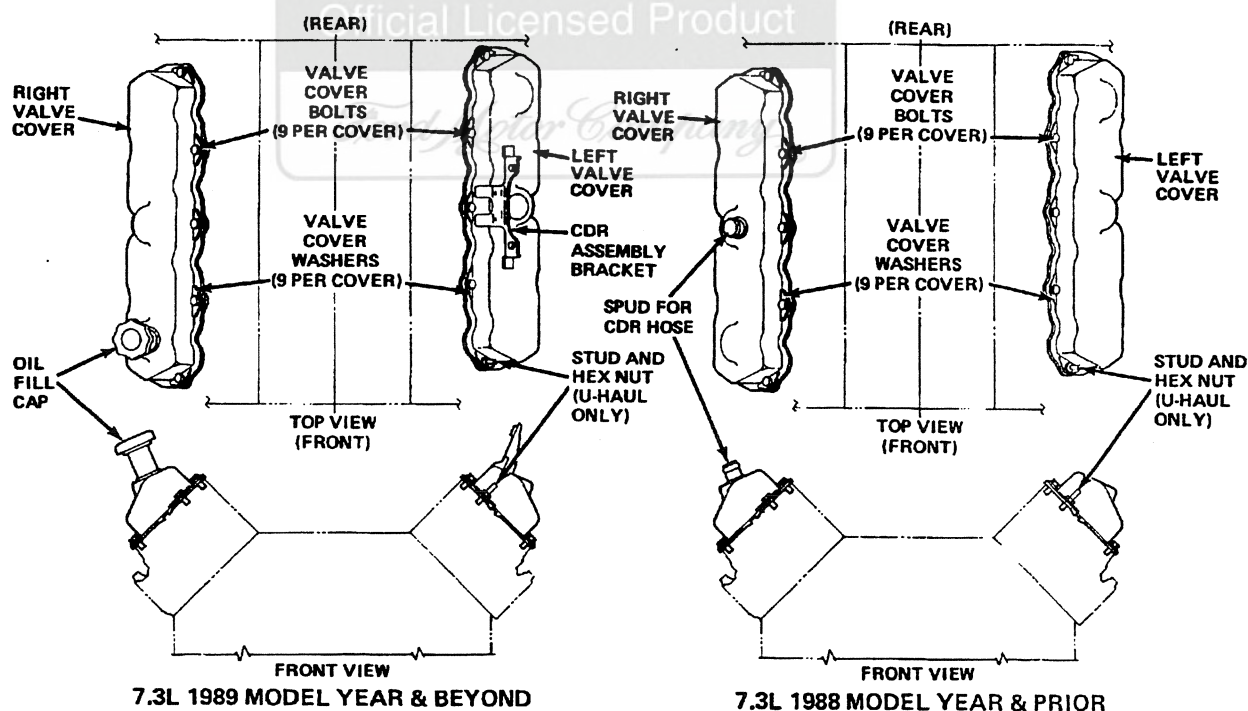


Figure 3.6. Valve Cover Removal

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Removal & Reassembly) – Continued

##### ■ Removal – Continued

##### ■ Valve Cover Removal

1. Remove nine valve cover bolts and washers from the right and left side (Figure 3.6). Remove valve covers and gaskets.
2. Remove valve rocker arm post mounting bolts, Figure 3.7. Loosen each pair of bolts evenly.
3. Remove valve lever, posts and retainer, as an assembly and identify each so they are returned to their original positions.

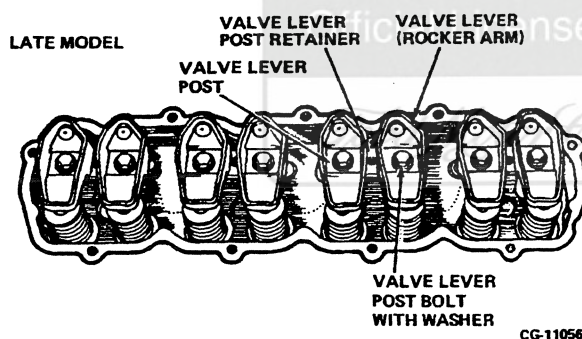


Figure 3.7. Valve Lever Assembly

##### ■ Valve Lever Assembly Disassembly

#### IMPORTANT

THE VALVE LEVER ASSEMBLY DOES NOT REQUIRE DISASSEMBLY OF ITS INDIVIDUAL COMPONENTS.

HOWEVER, IN THE EVENT THE VALVE LEVER ASSEMBLY COMPONENTS BECOME DISLODGED DURING SERVICE, REASSEMBLY INSTRUCTIONS ARE PROVIDED.

##### ■ Valve Lever Cleaning and Inspection

- Clean all parts with a suitable solvent and use filtered compressed air to dry the parts.
- Inspect the valve stem contact surface of each valve lever and replace any valve lever which is deeply pitted. Inspect the valve lever bolts for thread damage, excessive wear or looseness in the cylinder head. Replace as required.

##### ■ Valve Lever Reassembly

1. If components become dislodged during service, reassemble the valve lever assembly component parts shown in Figure 3.8, as follows:

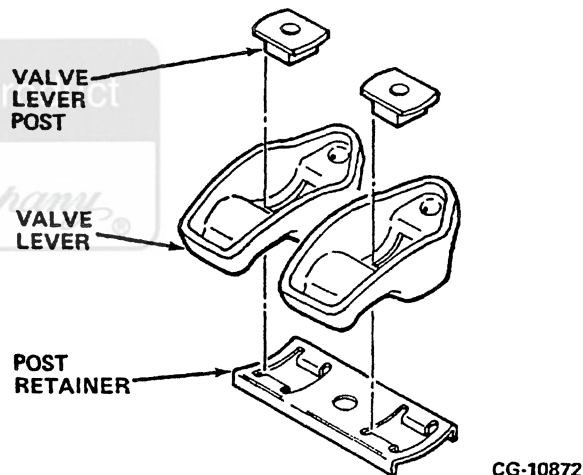


Figure 3.8. Valve Lever Assembly Components

- a. Place the valve lever post onto the valve lever bolts, then insert the bolt head into a 1/2 in. socket, Figure 3.9. The bolt will align the post in the valve lever while the socket acts as a holding fixture.

#### IMPORTANT

DURING VALVE LEVER REASSEMBLY, THE VALVE LEVER COMPONENTS MUST BE REASSEMBLED IN THEIR ORIGINAL LOCATION. DO NOT INTERMIX COMPONENTS.

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

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### CYLINDER HEAD (Removal & Reassembly) – Continued

#### ■ Valve Lever Reassembly – Continued

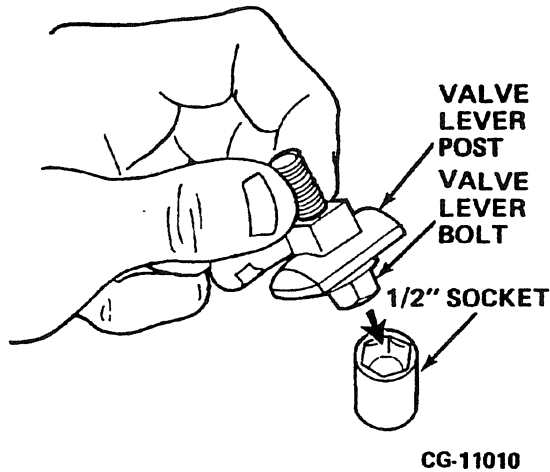


Figure 3.9. Valve Lever Reassembly  
Step One

b. Place the valve lever over the post and bolt, which are held in place by the 1/2 in. socket as shown in Figure 3.10. Then position the retainer over the post and lever.

**NOTE:** Apply clean engine oil between the post and the valve lever.

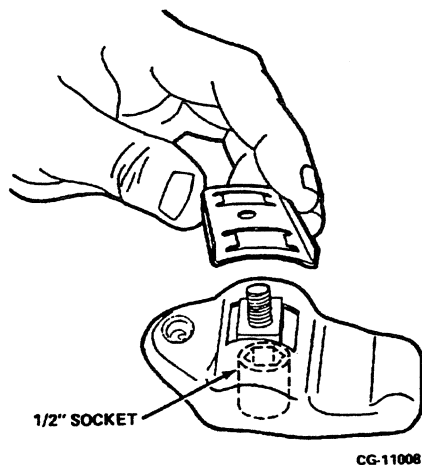


Figure 3.10. Valve Lever Reassembly  
Step Two

c. Place a 3/4 in. socket over the retainer as shown in Figure 3.11. Strike the socket squarely using a plastic hammer to install the retainer onto the post.

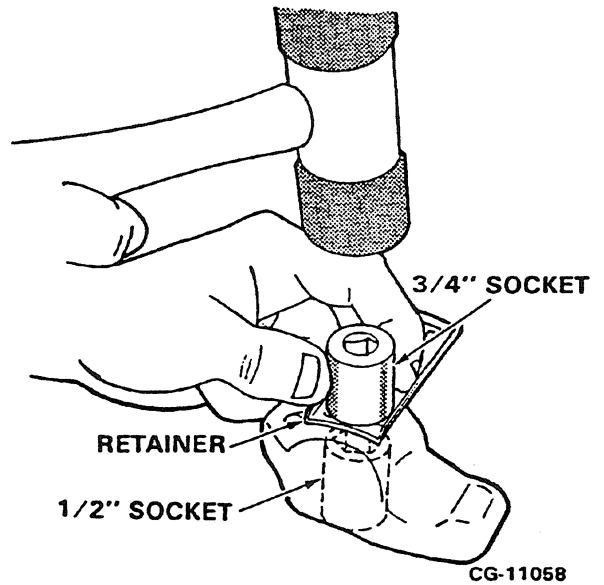


Figure 3.11. Valve Lever Reassembly  
Step Three

d. Repeat steps a through c for the second valve lever and post on the assembly. Refer to Figures 3.9 – 3.11. Set aside the bolt and 1/2 in. socket.

e. After both valve levers and valve lever posts are assembled, center the posts in the retainer using a blade screwdriver, as shown in Figure 3.12.

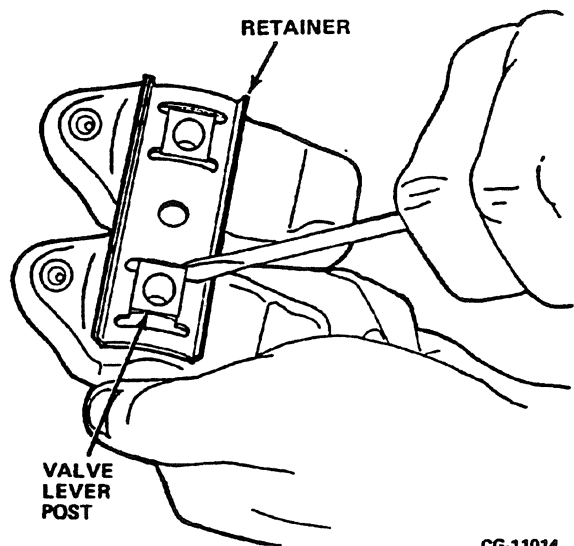


Figure 3.12. Post and Retainer Align  
Step Four

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Removal & Reassembly) –Continued

##### ■ Push Rod Removal

1. Remove the push rods and identify each so they are returned to their original positions during installation. Refer to Figure 3.13.

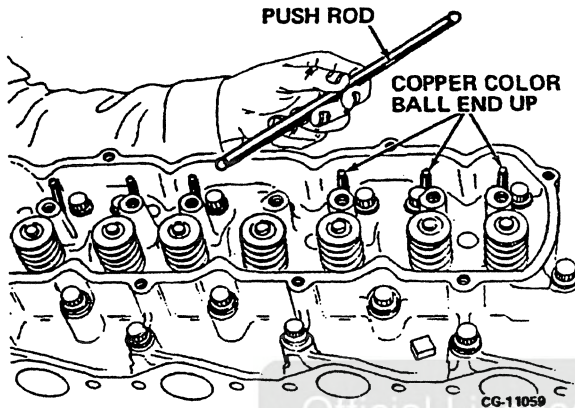


Figure 3.13. Push Rod Removal

##### ■ Cylinder Head Removal

1. **Engines w/Serial No. 823 762 and Below:** Remove the seventeen cylinder head "plain head" mounting bolts and washers. Refer to Figure 3.14.

**Engines w/Serial No. 823 763 and Above:** Remove the seventeen cylinder head "flange head" mounting bolts. Refer to Figure 3.14

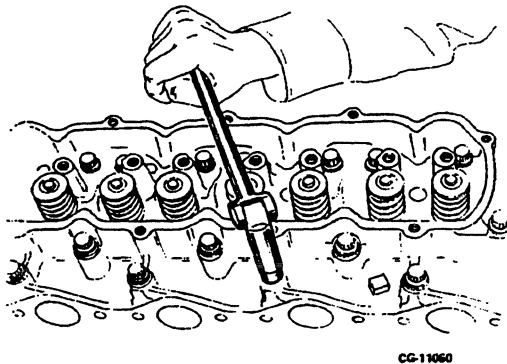


Figure 3.14. Cylinder Head Bolt Removal

2. Attach lifting eyes or equivalent to each end of the cylinder head.
3. Install a suitable lifting sling (SE-1896) to lifting eyes and carefully remove each cylinder head.

4. Remove cylinder head gasket. Be careful not to damage cylinder head locating dowel sleeves.

#### CAUTION !



Pre-combustion chambers may fall out of cylinder head upon removal. Mark (with ink) location of pre-combustion chambers for reassembly. **DO NOT** mark with a steel stamp.

##### ■ Cylinder Head Cleaning

1. With valves installed to protect the seats, remove deposits and gasket material from combustion chambers, valve heads and gasket surface with a scraper and a wire brush. **BE CAREFUL NOT TO DAMAGE CYLINDER HEAD GASKET SURFACE.**
2. Use a suitable solvent to remove dirt, grease and other deposits; clean all bolt holes; be sure gasket surfaces, oil return and water passages are clean. Blow out with filtered compressed air.
3. Clean cylinder head bolt threads with a bristle brush. **DO NOT USE A STEEL OR BRASS BRUSH!** Wash all bolts and washers with a suitable solvent and dry thoroughly.

**NOTE:** Make sure crankcase threads and cylinder head bolts are clean. **DIRT IN THREADS OR DAMAGED THREADS MAY CAUSE BINDING AND RESULT IN A FALSE TORQUE READING.**

##### ■ Cylinder Head Inspection

1. Using an outside micrometer, measure cylinder head thickness at four locations. If minimum specification is not met, replace the head.
2. Inspect the cylinder head as follows:

- Examine the cylinder heads visually for cracks using dye penetrant (spray dye) check methods.

**NOTE:** Spray dye will expose hair line cracks or sand holes. Replace cylinder head if cracks are found.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

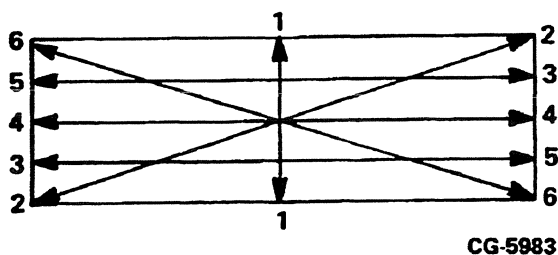
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### CYLINDER HEAD (Removal & Reassembly) -Continued

#### ■ Cylinder Head Inspection - Continued

- Visually inspect combustion chamber inserts for cracking beyond the "FIRE RING". Refer to **Figure 3.25** for pre-combustion chamber cracking criteria.
- Visually inspect gasket and sealing surfaces for scratches or marks which may cause leakage after assembly.
- Using a straightedge and feeler gauge, check the cylinder head gasket surface for warpage utilizing the checking pattern shown in **Figure 3.15**. Replace cylinder head if beyond specified limits (see **SPECIFICATIONS**).

**NOTE:** Prior to checking cylinder head gasket surface for warpage, remove the pre-combustion chamber inserts to avoid erroneous readings. (Refer to **Figure 3.24**).



**Figure 3.15. Cylinder Head Checking Pattern**

#### IMPORTANT

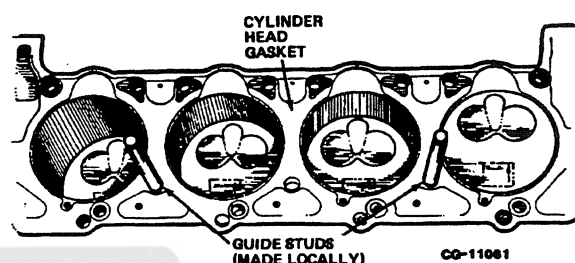
REPLACE CYLINDER HEAD IF ANY ONE OF THE INSPECTION CRITERIA DOES NOT MEET SPECIFICATIONS. CYLINDER HEADS CANNOT BE RESURFACED, BECAUSE REMOVAL OF BOTTOM DECK MATERIAL WILL RESULT IN PISTON TO VALVE CONTACT

#### ■ Cylinder Head Installation

1. Install cylinder heads as follows:

**NOTE:** New cylinder heads and gaskets are interchangeable from one cylinder bank to another. Used cylinder heads should be installed in their original positions using new gaskets.

- a. Carefully position new cylinder head gaskets (with "UP", facing installer) onto the pre-cleaned crankcase using locating dowels as shown in **Figure 3.16**.



**Figure 3.16**

#### CAUTION !



**Do not apply sealer to head gasket surfaces**

- b. Check to be sure all pre-combustion chambers are installed in the cylinder head. If not, apply clean grease to the mounting edge of the combustion chamber(s) and install in cylinder head. Tap lightly with plastic hammer, if necessary.

**NOTE:** When installed, the pre-combustion chambers are acceptable with a .0025" protrusion above the cylinder head deck or a .0025" recession below the cylinder head deck.

- c. Lubricate all cylinder head bolts with clean engine oil.

#### IMPORTANT

LIGHTLY LUBRICATE BOLT THREADS AND MATING SURFACES OF BOLT HEADS AND WASHERS WITH ENGINE OIL. TOO MUCH OIL WILL CAUSE HYDROSTATIC LOCK AND GIVE INCORRECT TORQUE READING.

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Removal & Reassembly) -Continued

#### ■ Cylinder Head Installation - Continued

##### CAUTION !



Do not use anti-seize compounds, grease or any other lubricant except engine oil. Other lubricants have an adverse effect on torque value.

##### CAUTION !



Do not drop cylinder head on gasket or slide it across gasket as either action would damage combustion, oil and coolant seals as well as hollow dowels resulting in leakage.

Also use care when installing cylinder head to prevent pre-combustion chambers from falling into cylinder bores.

d. Install lifting sling (SE-1896) to cylinder head lifting eyes.

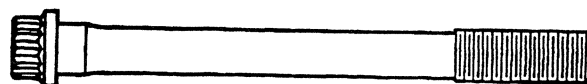
e. Carefully lower cylinder head and position it over sleeve (locating) dowels.

f. **Engines w/Serial No. 823 762 and Below:**  
Install cleaned "plain head" cylinder head bolts and washers through sleeve dowels in head into crankcase.

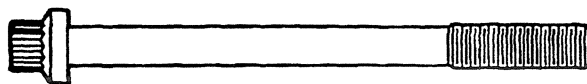
**Engines w/Serial No. 823 763 and Above:**  
Install cleaned "flange head" cylinder head bolts through sleeve dowels in head into crankcase.

##### IMPORTANT

**DO NOT USE WASHERS WHEN INSTALLING "FLANGE HEAD" BOLTS! USE OF WASHERS WILL RESULT IN IMPROPER THREAD ENGAGEMENT. (REFER TO FIGURE 3.16A.**



"PLAIN HEAD" CYLINDER HEAD BOLT



"FLANGE HEAD" CYLINDER HEAD BOLT

CG-13328

Figure 3.16A Cylinder Head Bolt Comparison

g. Tighten cylinder head bolts to specified torque. Refer to "Special Torques" in this section.

2. Insert the valve lifter push rods in their respective positions with the copper colored end up.

##### IMPORTANT

**THE TWO BALL ENDS OF THE PUSH RODS ARE DIFFERENT MATERIALS TO ENSURE THE COMPATIBILITY OF METALLIC MATING SURFACES OF THE VALVE LEVER, PUSH ROD AND VALVE LIFTER. COPPER COLORED END MUST BE INSTALLED UP.**

**NOTE:** On higher mileage engines, cleaning push rods is necessary to identify the copper colored ball end.

The copper colored ball end will exhibit a shiny/polished pattern on the upper half (180°) of the ball and the lower half will appear more tarnished/blackened than the original copper color. The bottom/lifter end of the push rod will appear totally polished and shiny.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

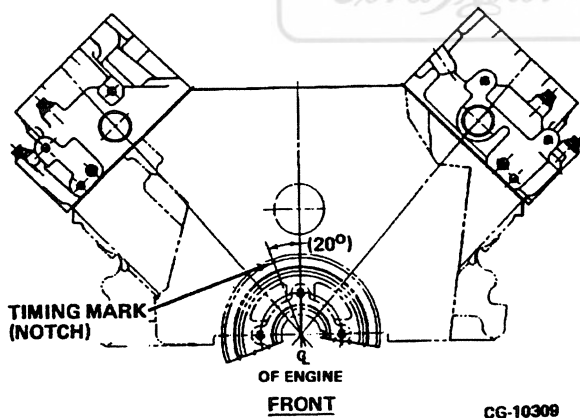
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### CYLINDER HEAD (Removal & Reassembly) -Continued

#### ■ Cylinder Head Installation - Continued

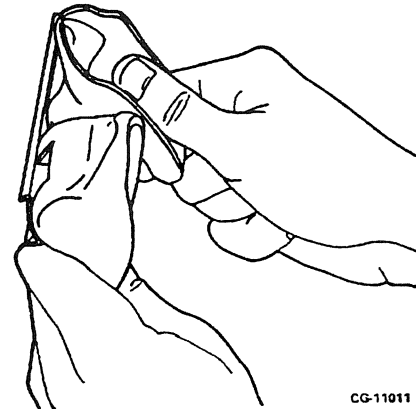
#### IMPORTANT

ROTATE ENGINE UNTIL TIMING MARKS ON VIBRATION DAMPER ARE APPROXIMATELY 20° BEFORE VERTICAL POSITION (11:00) AS VIEWED FROM THE FRONT OF THE ENGINE FIGURE 3.17. THIS POSITIONS ALL PISTONS BELOW TDC SO THE VALVES DO NOT CONTRACT THE PISTONS WHEN TIGHTENING THE VALVE LEVER ASSEMBLIES.



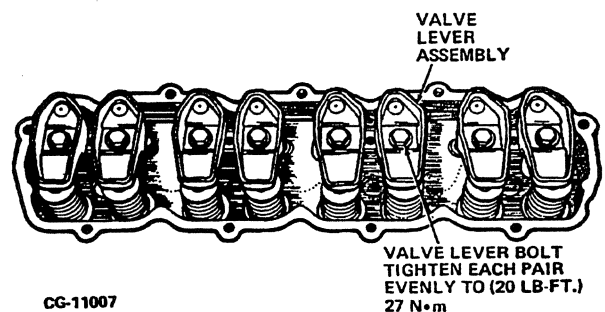
**Figure 3.17. Engine Crankshaft Vibration Damper Timing Mark Positioned For Valve Lever Post Bolt Torque (Damper is Behind Pulley) Timing Mark @ 11:00 [20° Before Vertical]**

3. If valve lever assemblies have been apart, rock the assembly back and forth to create clearance between the retainer and the valve lever. Refer to **Figure 3.18**.



**Figure 3.18. Valve Lever and Retainer Clearance (Required only if assemblies have been apart)**

- Insert each pair of valve lever assemblies onto the cylinder head assembly.
- Tighten each pair of valve lever bolts down evenly to the specified torque (see **SPECIFICATIONS**). Refer to **Figure 3.19**.



**Figure 3.19. Valve Lever (Rocker Arm) Installation**

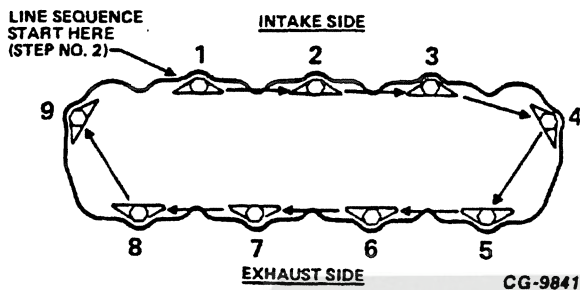
4. Replace valve cover gaskets and install valve covers. Tighten bolts to specified torque (see **SPECIFICATIONS**). Refer to **Figure 3.20**.

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

### CYLINDER HEAD (Removal & Reassembly) -Continued

#### ■ Cylinder Head Installation - Continued



**Figure 3.20. Valve Cover Bolt Torque**

Install and tighten bolts to 6 lbf-ft. (8 N.m) in line sequence shown above.

5. Reinstall the following: (Refer to appropriate manual section for procedures.)

- |                                    |  |
|------------------------------------|--|
| ● Valley Pan and Gasket            | ● Injection Pump (w/High Pressure Lines) |
| ● Intake Manifold                  | ● Glow Plugs                             |
| ● Exhaust Manifolds                | ● Glow Plug Controller                   |
| ● Oil Level Gauge Assy.            | ● Glow Plug Harness                      |
| ● Fuel Return Lines (Low Pressure) | ● Fuel Filter Assy.                      |
| ● CDR Assy.                        |  |

**CAUTION !**

Operating the engine with an inadequately filled coolant system may result in steam pockets which could cause cylinder head and/or gasket failure.

### CYLINDER HEAD (Reconditioning)

#### ■ Disassembly

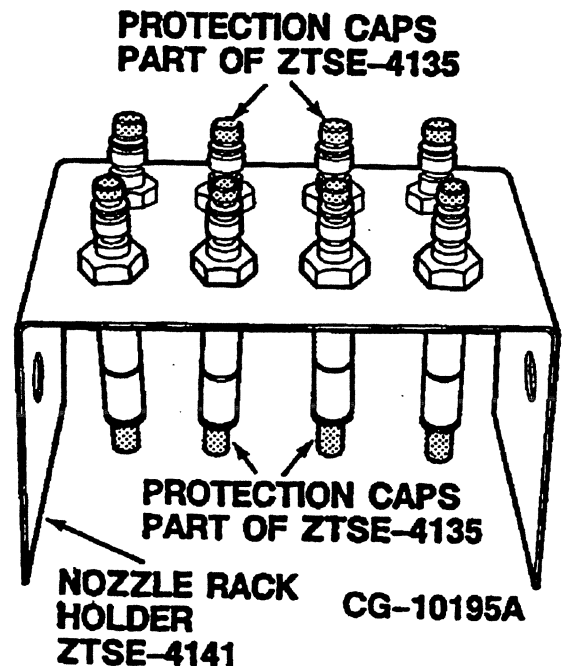
With cylinder head removed, disassemble as follows:

1. Remove injection nozzles by turning (CCW) counterclockwise. Pull nozzle assembly with copper gasket from the head.

**CAUTION !**

Be extremely careful not to damage nozzle tips during removal.

2. Place nozzle assemblies in holding rack (ZTSE-4141) to prevent damage to tips as they are removed from the heads, **Figure 3.21**. Use of this fixture permits replacing nozzles in their respective ports in the cylinder heads. Assure tips and tubing connections are capped with ZTSE-4135 protector caps.



**Figure 3.21. Nozzle Holder Rack**

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

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Page 15

### CYLINDER HEAD (Reconditioning)

#### ■ Disassembly

3. Remove glow plugs using appropriate deep socket.

#### IMPORTANT

TO PROTECT THE VALVE SEATS, REMOVE DEPOSITS AND GASKET MATERIAL FROM THE COMBUSTION CHAMBERS, VALVE HEADS AND GASKET SURFACE WITH A SCRAPER AND WIRE BRUSH BEFORE REMOVING THE VALVES FROM THE HEAD.

#### IMPORTANT

ENGINES BUILT AFTER S/N 520428 DO NOT USE THE SMALL NYLON INTAKE OIL SHIELD. SERVICE OF ENGINES BUILT WITH THE SMALL NYLON INTAKE OIL SHIELD REQUIRES THAT IT BE DELETED DURING REASSEMBLY.

DO NOT CONFUSE THE NYLON INTAKE VALVE STEM OIL SHIELD [LOCATED UNDER THE RETAINER] WITH THE RUBBER VALVE STEM SEAL [LOCATED AT THE VALVE GUIDE]. THE RUBBER SEAL MUST REMAIN IN PLACE.

#### ● MINERAL SPIRITS TEST

Prior to valve removal, squirt mineral spirits into each intake and exhaust port (one at a time). Inspect the valve seat areas for leakage. If leakage is present that valve seat must be repaired.

#### ● VALVE HEAD RECESSION (Relative to Deck)

Prior to valve removal, measure valve recession (Refer to Figure 3.59). If out of specifications, valve and valve seat require reconditioning or replacement.

4. Remove valves from cylinder head as follows:

- a. Using valve spring compressor tool ZTSE-1846 (Figure 3.22) compress the valve springs.
- b. Remove the retainer locks, retainer (with oil shield), spring w/damper, valve stem seal (intake only) and valve rotator.

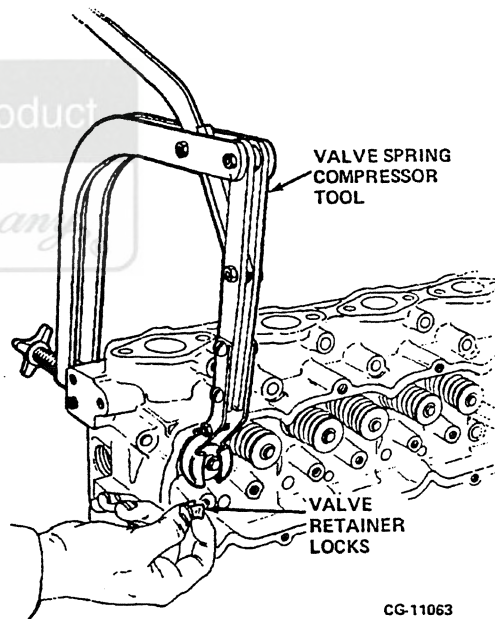


Figure 3.22. Removing Valve Retainer Locks

#### IMPORTANT

KEEP VALVES AND THEIR RELATED PARTS TOGETHER SO THEY MAY BE REINSTALLED IN THEIR RESPECTIVE POSITIONS.

5. If pre-combustion chamber inserts are to be reused, remove as follows: Using a brass rod inserted in the nozzle bore, the pre-combustion chamber insert can be driven out of the cylinder head with a hammer. Refer to Figure 3.23.

## SERVICE MANUAL

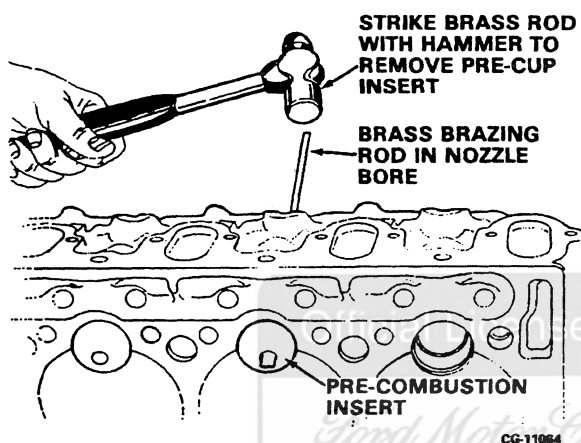
### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Reconditioning)

##### ■ Disassembly

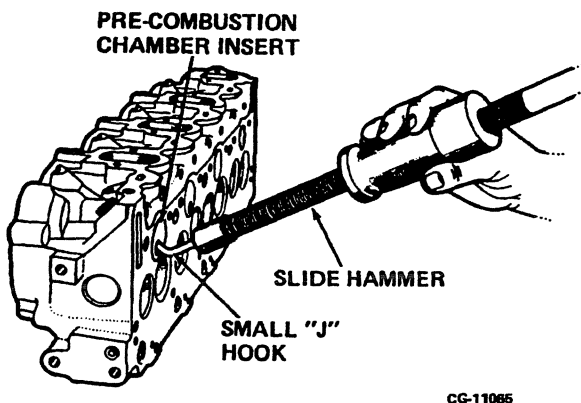
### IMPORTANT

**GLOW PLUGS MUST BE REMOVED WHEN USING THIS METHOD.**



**Figure 3.23. Removing Pre-Combustion Inserts which are to be Reused**

The pre-combustion chamber can also be removed with a "J" hook and slide hammer, Figure 3.24.



**Figure 3.24. Alternate Method of Removing Pre-Combustion Chamber Inserts**

**NOTE:** The slide hammer method can crack the pre-combustion chamber insert.

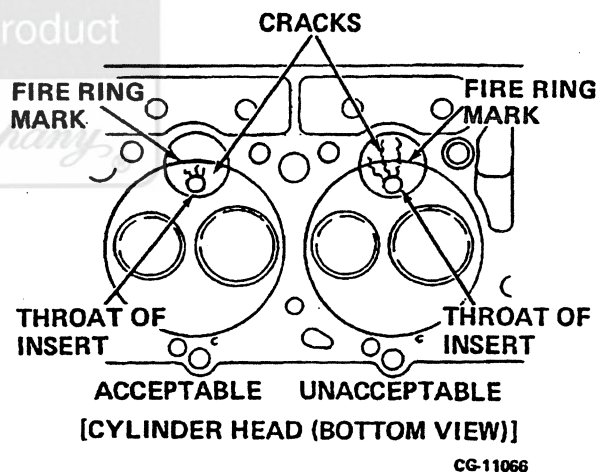
##### ■ Pre-Combustion Chamber

##### ● Inspection

1. Clean the pre-combustion chamber insert and visually inspect for cracks and burning.

### IMPORTANT

**CRACKING IS ACCEPTABLE FROM THE THROAT (FIGURE 3.25); HOWEVER, CRACKING PAST THE FIRE RING MARK IS UNACCEPTABLE. THROAT BURNING IS UNACCEPTABLE. REPLACE UNACCEPTABLE PRE-COMBUSTION CHAMBERS.**



**Figure 3.25. Pre-Combustion Chamber Cracking**

##### ● Installation

Refer to cylinder head reassembly in this section.

##### ■ Cylinder Head Core Plug

##### ● Inspection

1. Visually inspect core plugs for evidence of leakage (rust, small cracks or wetness).
2. Remove and install plugs as inspection warrants.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 17

### CYLINDER HEAD (Reconditioning) – Continued

#### ■ Disassembly – Continued

##### ● Removal

**NOTE:** Cylinder head core plugs should not be disturbed unless evidence of leakage exists.

1. Drill or punch a small hole in the center of the plug and install a sheet metal screw.
2. Pry the plug from its bore with a pry bar.

##### ● Cleaning

1. If core plugs are removed, flush and blow out any debris from the cylinder head.

##### ● Installation

1. Coat the outer edge of a new plug with Aviation Permatex® #3.
2. Use the expansion plug replacer (ZTSE-4155A) and a hammer as shown in Figure 3.26.
3. Install new core plug flush with the bottom edge of the chamfer in the cylinder head.

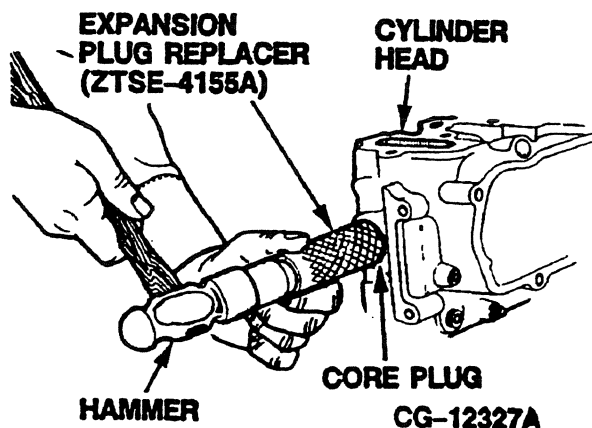


Figure 3.26. Installing Cylinder Head Core Plugs

#### ■ Steel (Seal) Balls

##### ● Inspection

1. Visually inspect seal balls for evidence of leakage (rust, small cracks or wetness).

2. Remove and install seal balls as inspection warrants.

**NOTE:** Each cylinder head contains four 13/32 in. steel (seal) balls located in passage holes on the exhaust manifold side of the cylinder head. The balls seal coolant flow through the cross drilled passages which provide positive coolant flow to the valve seat areas. (Refer to Figure 3.26A).

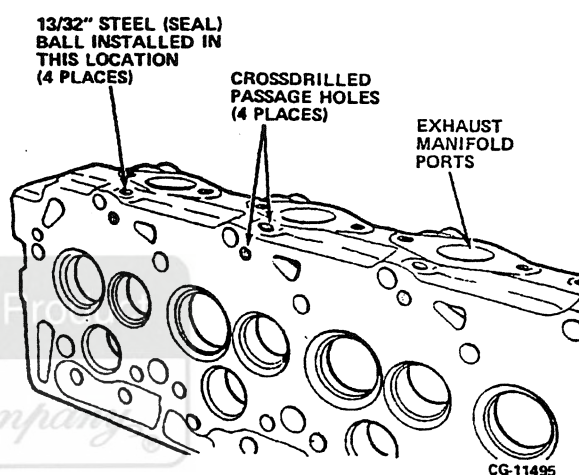


Figure 3.26A. Crossdrilled Passages in Cylinder Head (Bottom View)

##### ● Removal

**NOTE:** Cylinder head steel (seal) balls should not be disturbed unless evidence of leakage exists.

1. Fabricate a seal ball removal tool as follows: (Refer to Figure 3.26B)
  - a. Using a 1/4 in. Allen wrench, cut or grind the "J" bend so a 3/4 in. protrusion is present.
  - b. Weld either a square or round piece of bar stock to the Allen wrench, forming a tee handle.

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

### CYLINDER HEAD (Reconditioning) - Continued

#### ■ Steel (Seal) Balls - Continued

#### ● Removal - Continued

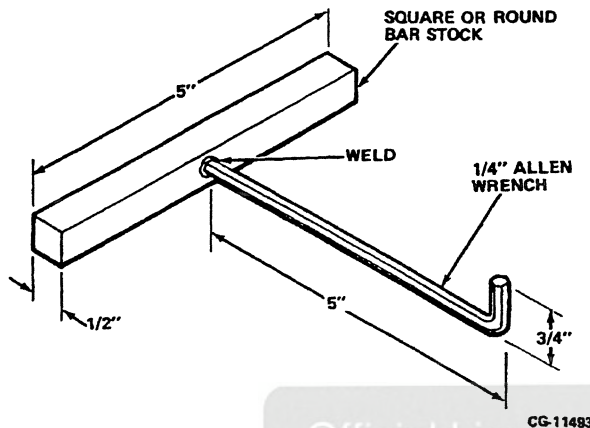


Figure 3.26B. Fabricate Seal Ball Remover Tool

2. Insert the "J" bend of the remover tool into the orifice in the cylinder head, where the ball is to be removed. Apply downward pressure to the "tee" handle and the ball will pop out. (Refer to Figure 3.26C)

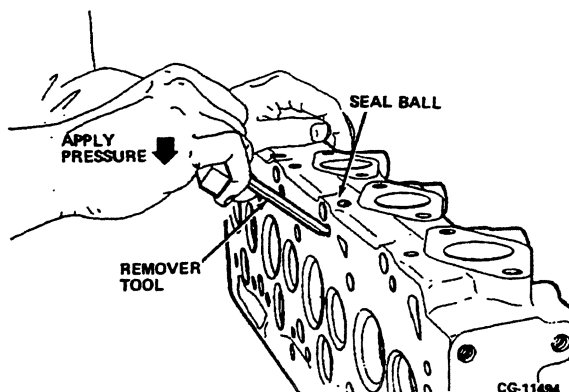


Figure 3.26C. Remove Steel (Seal) Ball

#### ● Cleaning

1. If ball(s) are removed, clean passage(s) with a suitable brush and blow out with filtered compressed air.

#### ● Installation

1. Install a new 13/32 in. steel (seal) ball as follows: (Refer to Figure 3.26D).

### IMPORTANT

**TO PREVENT CYLINDER HEAD CRACKING, DO NOT ATTEMPT TO INSTALL A LARGER DIAMETER STEEL (SEAL) BALL THAN SPECIFIED.**

- Place new ball over orifice at side of cylinder head.
- Apply Loctite® hydraulic sealant to ball.
- Using a punch and hammer, drive ball into orifice until seated.

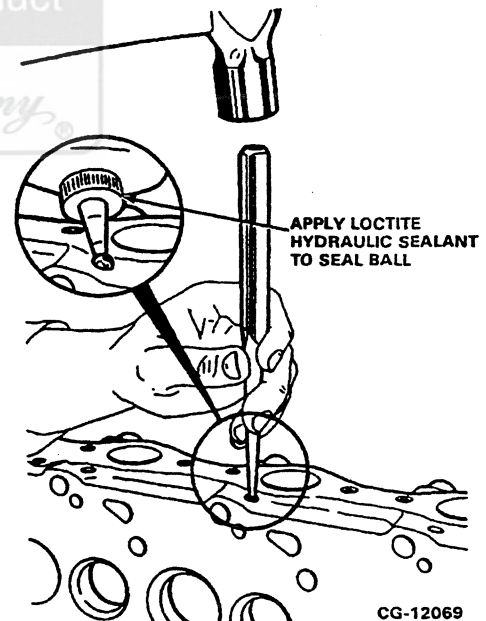


Figure 3.26D. Installing a New Steel (Seal) Ball

#### ■ Valves

#### ● Cleaning

1. Remove all carbon from valve stems and valve heads using a suitable solvent and a fine brass wire brush.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 19

### CYLINDER HEAD (Reconditioning) - Continued

#### ■ Valves - Continued

#### ● Inspection

1. Visually inspect each valve, replacing any that show evidence of burn marks, warpage, scuffing or bending.
2. Measure each valve stem for wear using micrometer to measure valve stem diameter. Measure at three locations 90° apart. Refer to "SPECIFICATIONS". Replace valves if out of specification.
3. Measure each valve stem and guide for fit of valve stem to guide clearance (running clearance). Refer to "SPECIFICATIONS". Replace valve or valve guide as required.
4. If valves are in serviceable condition, reface as required.
  - a. Maintain a minimum valve face margin across the entire valve face, Figure 3.27. Refer to "SPECIFICATIONS". Use a caliper to measure at four locations.

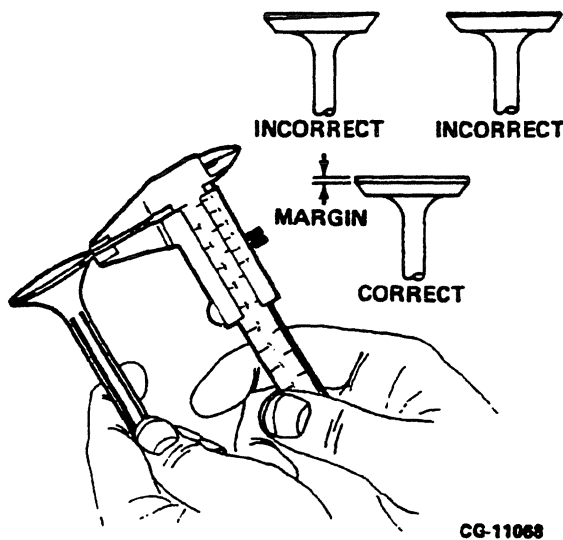


Figure 3.27. Measure Valve Face Margin

- b. Maintain valve face angles as shown, Figure 3.28.

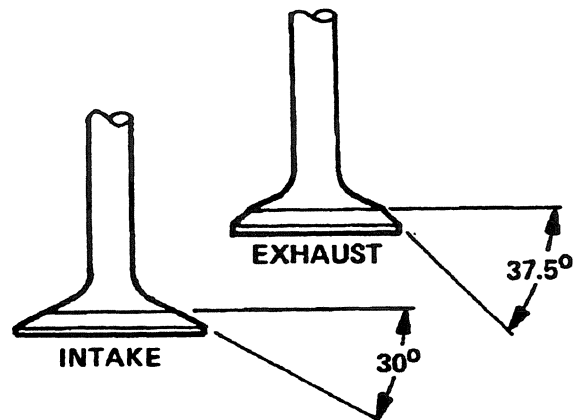


Figure 3.28. Valve Face Angles

**NOTE:** An insufficient margin will not provide proper heat dissipation and lead to warpage or breakage.

5. Resurface valve face as follows:

- a. Refer to valve face dimensions in "SPECIFICATIONS".
- b. Install valve in grinder and carefully dress the wheel to the proper angle.
- c. Remove only the minimum amount of material necessary to true up the valve face. Refer to Figure 3.29.
- d. Replace valve if margin is less than the specified minimum, after grinding.
- e. Check valve face runout, after resurfacing, with a dial indicator. Replace valve if beyond "SPECIFICATION".

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Reconditioning) - Continued

##### ■ Valves - Continued

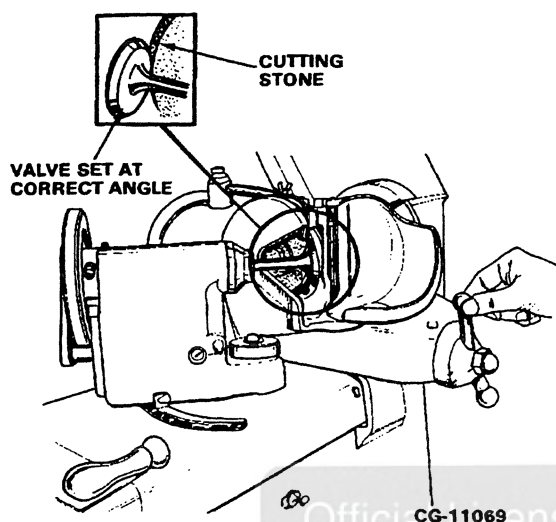


Figure 3.29. Grinding Valve Face Angle

##### ● Valve Guides

##### ● Cleaning

1. Using a nylon brush, soap and water, clean the valve guide bores in the cylinder head.
2. Blow out any residue with filtered compressed air.

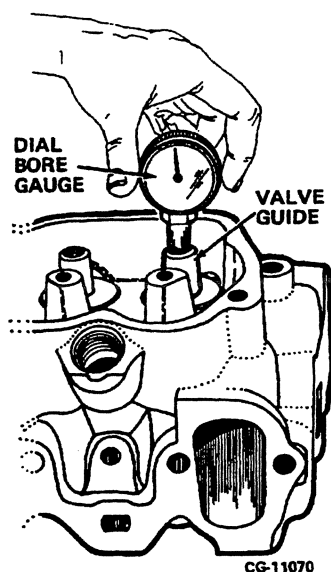


Figure 3.30. Checking Valve Guide Bore

##### ● Inspection

1. Using an appropriate valve guide bore gauge or a telescoping gauge and micrometer, check for proper guide bore diameter (see SPECIFICATIONS), Figure 3.30.
2. Replace guides having bore diameters, tapers and/or run-out beyond specified limits.

#### IMPORTANT

VALVE GUIDES ARE CAST INTO THE CYLINDER HEAD AND MUST BE DRILLED OUT TO INSTALL SERVICE GUIDES.

##### ● Removal and Replacement

(Use ZTSE-4157 Valve Guide Service Tools)

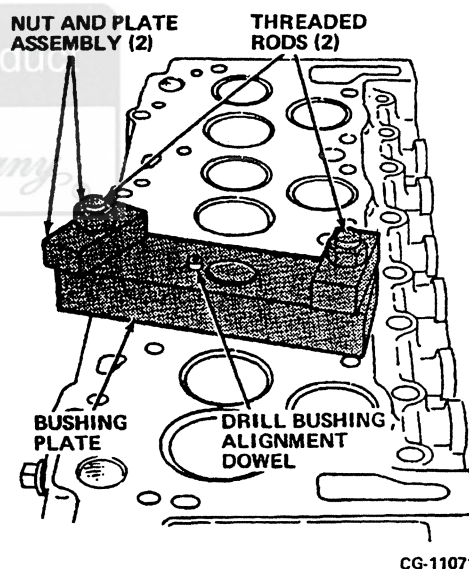


Figure 3.31. Bushing Plate Mounted Over Valve Guide

1. With cylinder head mounted in a holding fixture or on wood blocks, place the bushing plate over the guide to be serviced. Use the two threaded rods, the two nut and plate assemblies and the bushing plate. **DO NOT** tighten at this time. Refer to Figure 3.31.
2. Place the aligning tool through the hole in the bushing plate and into the valve guide in the cylinder head. The hole in the bushing plate is now concentric with the valve guide. Refer to Figure 3.32.

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 21

### CYLINDER HEAD (Reconditioning) – Continued

#### ■ Valve Guides–Continued

#### ● Removal and Replacement – Continued

3. Tighten the nuts holding the bushing plate.

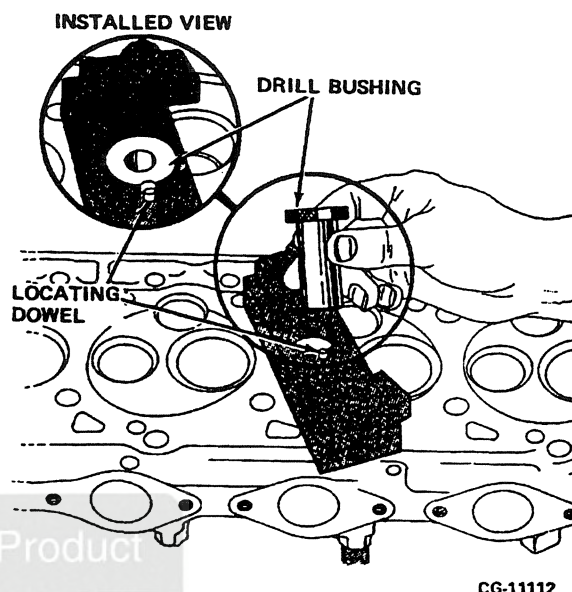
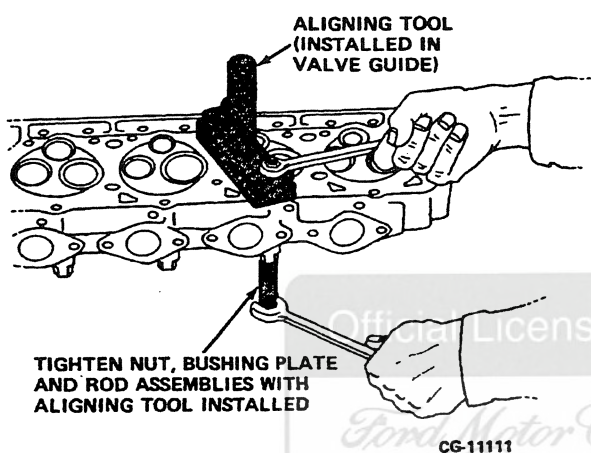


Figure 3.32 Aligning Tool in Bushing Plate  
and Valve Guide

### IMPORTANT

#### Required Tools:

Valve Guide Service Tools  
ZTSE-4157 consists of:

QTY	DESCRIPTION
1	Bushing Plate
2	Threaded Rods w/Nuts
1	Aligning Tool
1	Drill Bushing 19/32"
1	Core Drill
1	Pilot
1	End Mill
1	Reamer Bushing
1	Reamer
1	Guide Driver
1	Finish Reamer

Figure 3.33. Drill Bushing in Valve Guide

4. Remove the aligning tool (Figure 3.32) and insert the 19/32" drill bushing (Figure 3.33).

5. Using a 1/2" electric drill with the drive adapter installed in the chuck, drill out the cast valve guide, refer to Figure 3.34.

Lubricate with cutting oil during drilling.

### IMPORTANT

**DRILL SPEED SHOULD NOT  
EXCEED 600 RPM.**

## SERVICE MANUAL

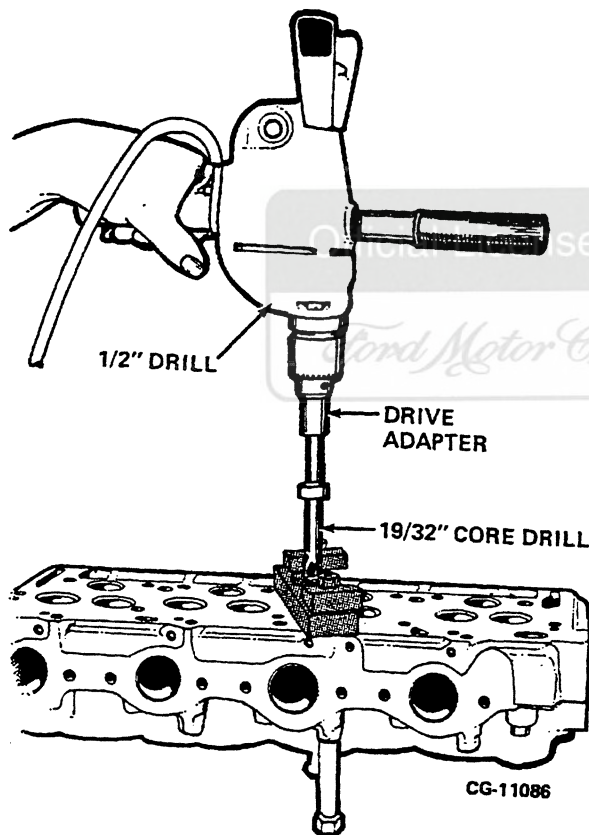
### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Reconditioning) – Continued

##### ■ Valve Guides–Continued

##### ● Removal and Replacement – Continued

6. Insert the 19/32" core drill into the drill bushing. Deburr valve guide bore. Refer to **Figure 3.35**.

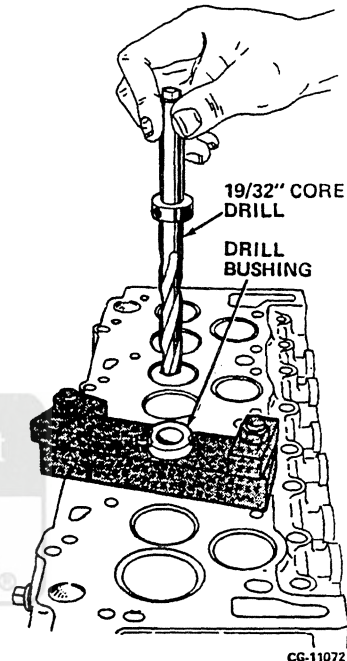


**Figure 3.34. Drilling Cast Valve Guide from Cylinder Head; Using Drive Adapter and 1/2" Drill**

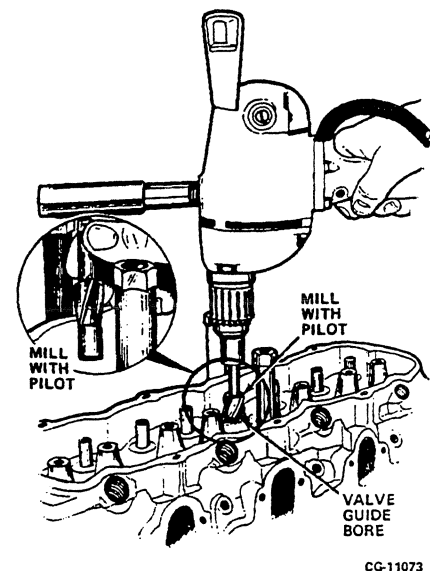
7. Remove the core drill and bushing.
8. Turn the cylinder head over to mill the remains of the cast guide on the top of the cylinder head.
9. Attach the pilot to the end mill. Refer to **Figure 3.36**.

10. Mill until guide bore is flush with spring seat. Refer to **Figure 3.37**.

11. Turn the cylinder head over to the combustion chamber side.



**Figure 3.35. Core Drill Used to Deburr Valve Guide Bore**



**Figure 3.36. Milling Valve Guide Bores (Top View of Cylinder Head)**

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 23

### CYLINDER HEAD (Reconditioning) - Continued

#### ● Valve Guides-Continued

#### ● Removal and Replacement - Continued

14. Attach the drive adapter to a 1/2" drill and ream through the cylinder head. Refer to Figure 3.39.

15. Remove the reamer and bushing.

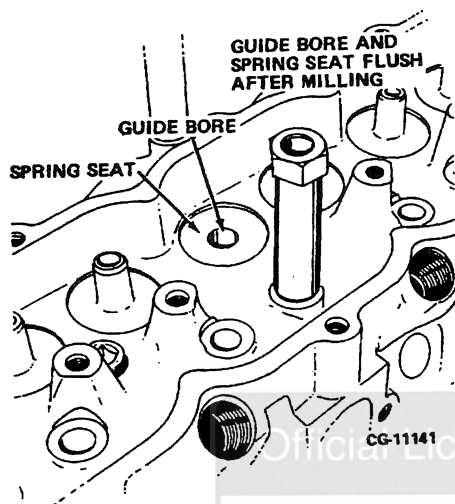


Figure 3.37. Guide Bore Flush with Spring Seat

12. Insert the reamer bushing into the bushing plate. (See Note.) Refer to Figure 3.38.

**NOTE:** Refer to Section 3, page 3 for valve guide insert bore diameter specification.

13. Dip the first three inches of the reamer in cutting oil and install it into the reamer bushing. Refer to Figure 3.38.

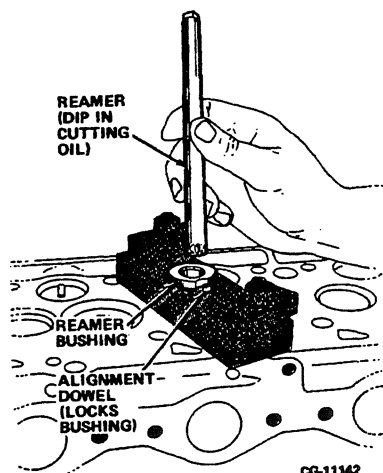


Figure 3.38. Set Up for Reaming Valve Guide Insert Bore in Cylinder Head

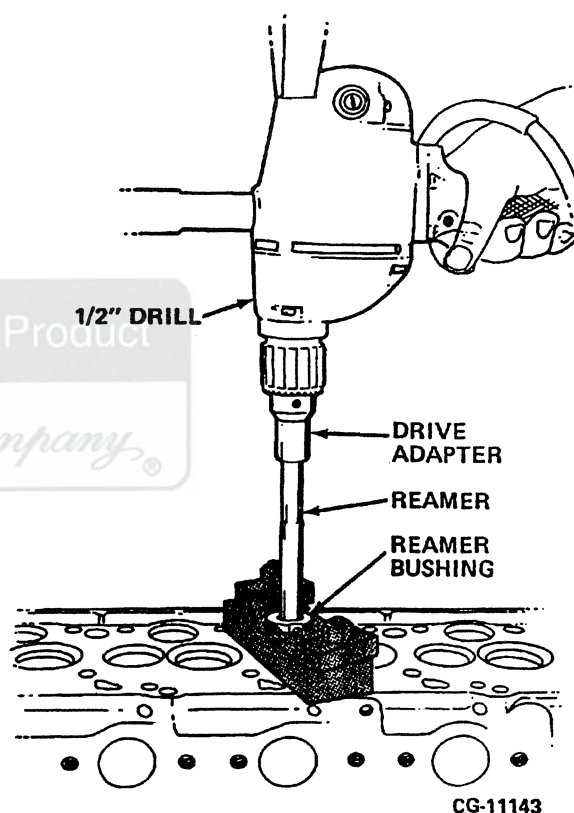


Figure 3.39. Reaming Valve Guide Bore in Cylinder Head

16. Position a new valve guide on the valve guide driver. Refer to Figure 3.40.

17. Lubricate valve guides and bore with clean engine oil prior to assembly.



## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Reconditioning) - Continued

- Valve Guides-Continued
- Removal and Replacement - Continued

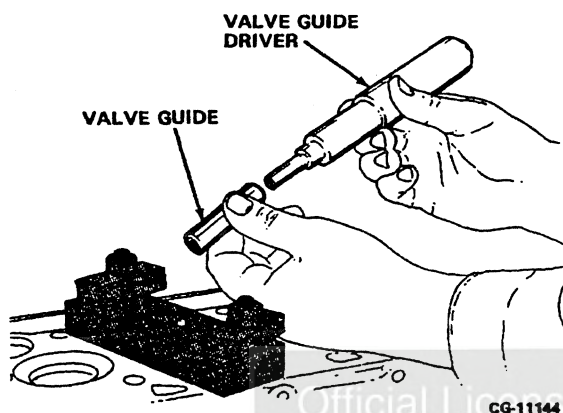


Figure 3.40. Positioning Valve Guide onto Driver

18. Insert the valve guide through the bushing plate and drive the guide into the head until the driver stops on the bushing plate (Figure 3.41).

**NOTE:** Freezing the valve guide will assist in installation.

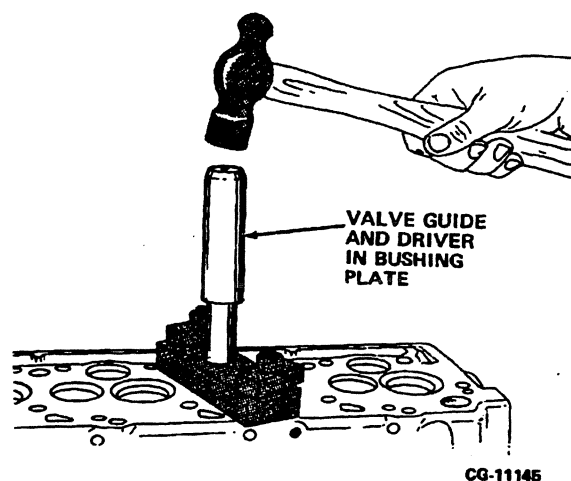


Figure 3.41. Installing Valve Guide Into Cylinder Head

19. Remove the bushing plate and use the valve guide finishing reamer (Figure 3.42) to finish the new valve guide insert bore. (See Note.)

**NOTE:** Refer to Section 3, page 2 for valve guide bore diameter specification.

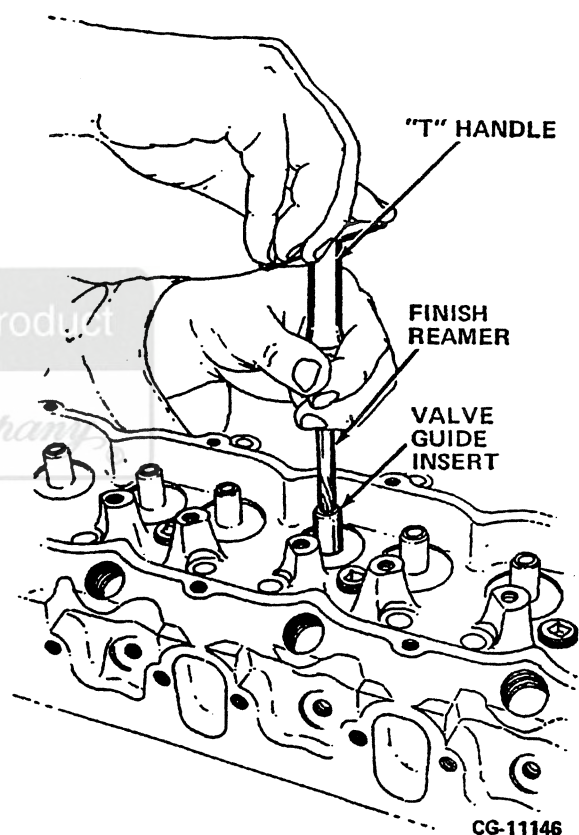


Figure 3.42. Finishing Ream on Valve Guide Inserts

#### ■ Valve Seats

#### ● Cleaning

1. Clean valve seat area using suitable solvent, prior to visual inspection.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 25

### CYLINDER HEAD (Reconditioning) – Continued

#### ● Valve Guides–Continued

#### ● Inspection

1. Visually inspect the exhaust valve seat inserts for wear, looseness, burned or cracked condition. These conditions may promote valve failure and require valve seat replacement.

#### ● Intake Valve Seat Resurfacing

1. Resurface intake valve seat as follows:

- Dress the grinding wheel to correct angle. Lightly lubricate and install correct size pilot into valve guide bore.
- Lower grinder head over pilot shank until wheel barely clears the valve seat. Turn on power. **GENTLY** apply grinding wheel to valve seat with little pressure other than weight of the wheel.
- Raise wheel frequently to prevent overheating.
- Grind seat to a smooth even surface.
- Check seat concentricity, roundness and valve face contact using Prussian Blue<sup>®</sup> as outlined.
- After grinding seats, it may be found that seats are wider than the specified width.

g. Correct wide valve seats as follows:

Use a 60° angle grinding stone to remove stock from the inner edge of the seat.

Use a 15° angle stone to remove stock from the outer edge of the seat to obtain the desired seat width. Refer to **Figure 3.48**.

2. After grinding the valve seat, check the seat for runout, using an appropriate dial bore indicator. Valve seat runout should not exceed limits shown in "SPECIFICATIONS".

**NOTE:** It is important to have the finished seat face contact the approximate center of the valve face. This can be checked using Prussian Blue<sup>®</sup>.

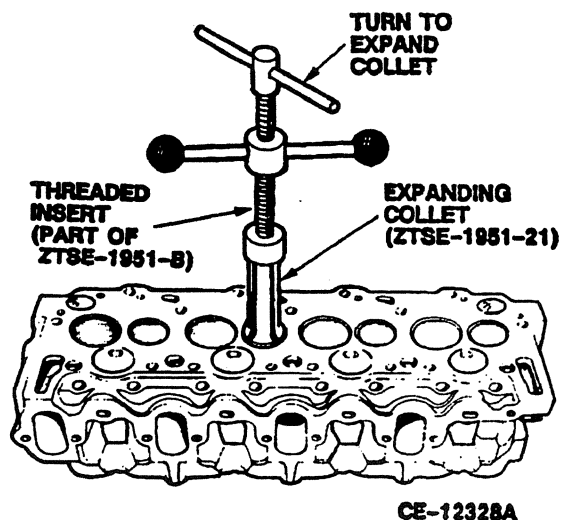
3. After resurfacing valves, insert valves in clean valve guide and check valve face contact with valve seat using Prussian Blue<sup>®</sup> as follows:

- Spread thin film of Prussian Blue(TM) on valve face. Insert valve into its guide.
- Apply pressure on exact center of valve head while making a quarter turn in the seat.
- Remove valve, inspect impression made on seat and on valve face.
- Bluing should appear around entire contact surface of valve face and valve seat to be acceptable. **CHECK SEVERAL TIMES TO PREVENT ERROR.** If acceptable, proceed with valve installation.

#### ● Removal (Exhaust Valve Seat Inserts)

1. Use exhaust valve seat remover (ZTSE-1951-B with ZTSE-1951-21) to remove defective valve seat inserts as follows:

- Use a pneumatic grinder to grind a groove around the inside circumference of the insert.
- Position the collet (ZTSE-1951-21) so the ridge of the collet will be inside the groove cut in step a. Mount the threaded shaft assembly and turn to fully expand the collet. Refer to **Figure 3.43**.



**Figure 3.43. Install Valve Seat Remover**

# SERVICE MANUAL

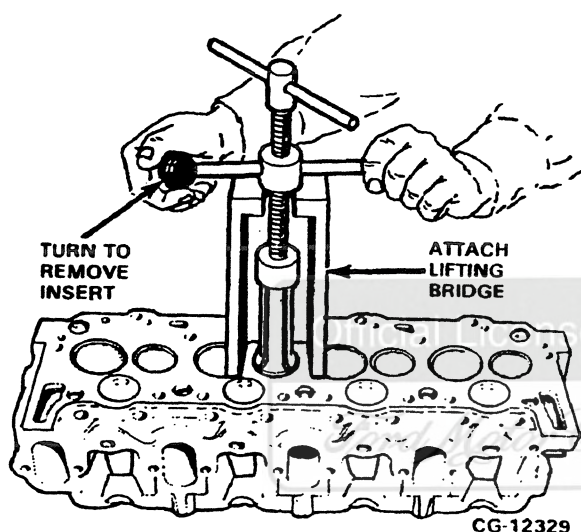
## CYLINDER HEAD AND VALVES

### CYLINDER HEAD (Reconditioning) - Continued

#### ■ Valve Seats - Continued

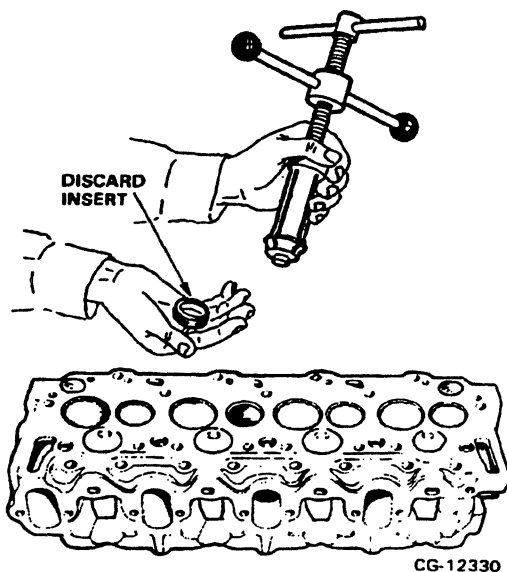
#### ● Intake Valve Seat Resurfacing - Continued

c. Install the lifting bridge and turn the crank handle to lift the insert from the cylinder head. Refer to Figure 3.44.



**Figure 3.44. Remove the Insert**

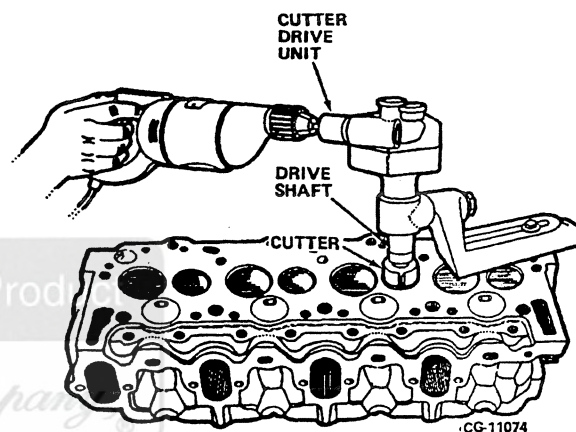
d. Turn the threaded shaft to release the insert from the collet. Discard the insert. Refer to Figure 3.45.



**Figure 3.45. Remove Insert from Collet**

### IMPORTANT

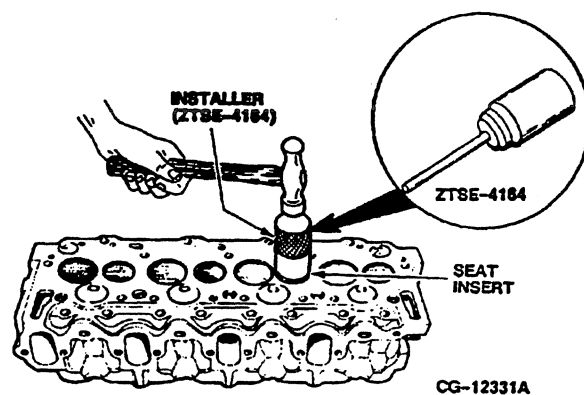
USE A VALVE SEAT CUTTING TOOL (ZTSE-1631-A) (FIGURE 3.46) TO DRESS BOTH THE BOTTOM AND CIRCUMFERENTIAL SURFACES. THE BOTTOM OF THE COUNTERBORE MUST BE SQUARE TO ASSURE GOOD SEATING OF THE INSERT.



**Figure 3.46. Dressing Exhaust Valve Seat Counterbore Using ZTSE-1631-A Cutting Tool**

1. Use exhaust valve seat insert installer ZTSE-4164 to install exhaust valve inserts as follows:

- Thoroughly chill inserts with dry ice or other means to facilitate their installation into the cylinder head.
- Use the installer tool (Figure 3.47) ZTSE-4164 and drive into place.



**Figure 3.47. Install Exhaust Valve Seat Insert**

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 27

### CYLINDER HEAD (Reconditioning) - Continued

#### ■ Valve Seats - Continued

#### ● Installation ( Exhaust Valve Seat Inserts)

2. The valve seats in the cylinder head, **Figure 3.48** must also be ground true to the angles and width shown on the specifications page. If the seat is wider than specified, it will be necessary to grind from the top and/or bottom of the seat until the proper seat width is obtained using a valve seat grinder.

**NOTE:** Only standard size exhaust valve seat inserts are supplied for service. Oversized seats are NOT available.

3. If exhaust valve seat width is not within specifications:

Use a 60° angle grinding stone to remove stock from the inner edge of the seat. Use a 15° angle stone to remove stock from the outer edge of the seat to obtain the desired seat width and valve positions. Refer to **Figure 3.49**.

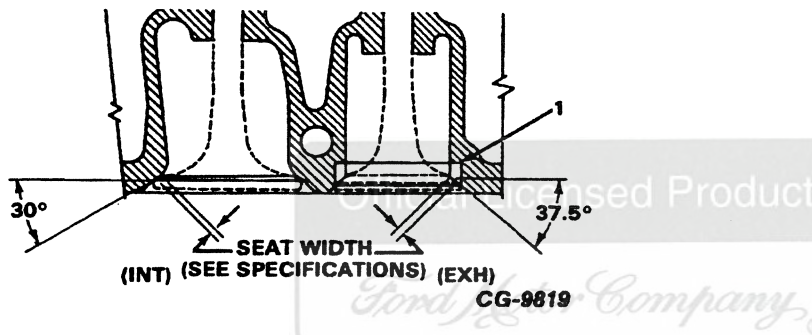
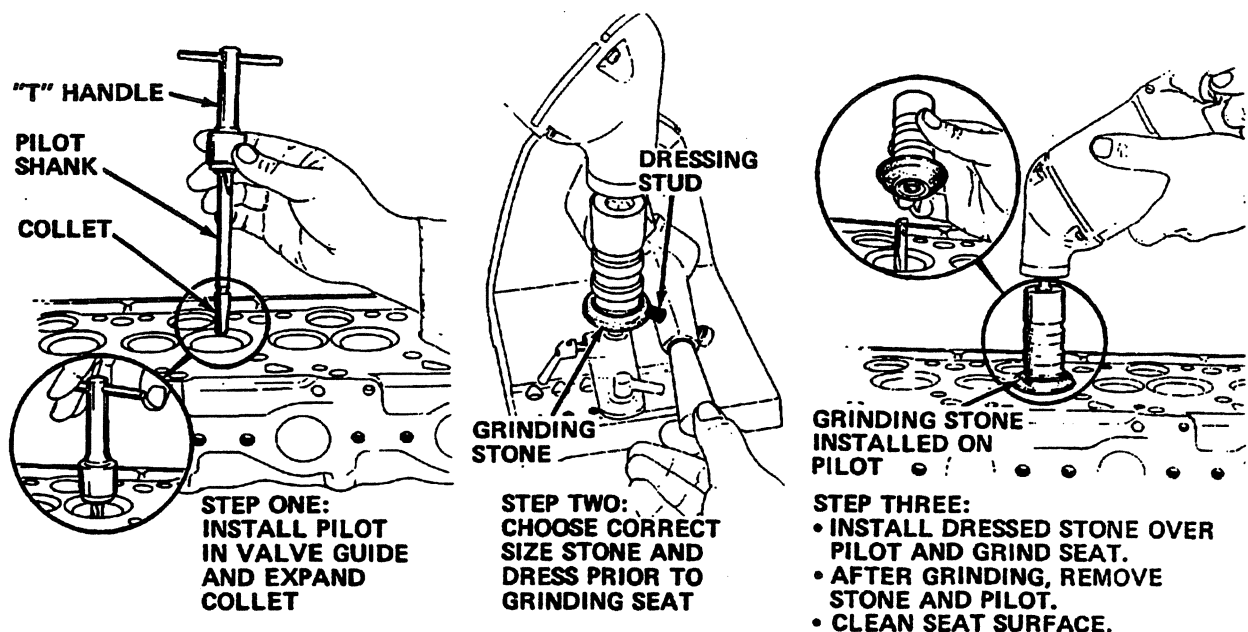


Figure 3.48. Valve Seat Width and Angles



CG-11151

Figure 3.49. Grinding Seat Using ZTSE-1631-69

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

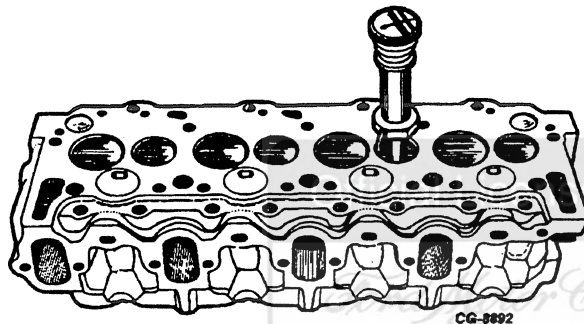
#### CYLINDER HEAD (Reconditioning) – ● Inspection

#### Continued

#### ■ Valve Seats – Continued

#### ● Installation ( Exhaust Valve Seat Inserts)–Continued

4. After grinding the seat, check the seat for runout, **Figure 3.50**. Valve seat runout should not exceed limits shown in "SPECIFICATIONS".



**Figure 3.50. Using Dial Bore Indicator Grinder Set for Checking Seat Runout**

5. It is important to have the finished seat face contact the approximate center of the valve face. Position the valves in the cylinder head. Place a thin coat of Prussian Blue<sup>®</sup> on each valve face and tap the valve lightly to its seat. Refer to valve resurfacing in this section for instructions for proper use of Prussian Blue<sup>®</sup>.

**NOTE:** This is merely for test and proof of results of refacing and reseating operations. A poor grind job cannot be corrected by lapping. Inspect each valve for seat dimensions as outlined in specifications and make any necessary corrections. The corrections should always be made on the seat and not the valve face.

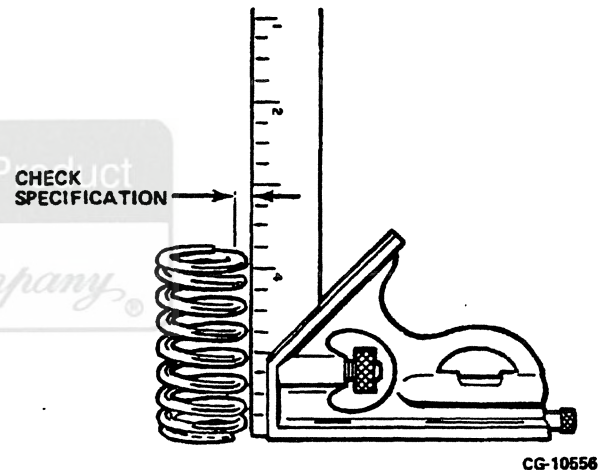
#### ■ Valve Springs

#### ● Cleaning

1. Clean all valve springs and seats in a suitable solvent.

1. Visually inspect valve spring with damper assembly for rust, pitting and cracks. Look for spring distortion.

2. Spring ends must be flat and square to prevent lateral loads on valve stem. Refer to **Figure 3.51**.



**Figure 3.51. Checking Valve Spring Squareness**

**NOTE:** Out of square springs place a side load on the stem causing rapid guide wear.

3. Refer to "SPECIFICATIONS" and test:

● Valve spring free length, **Figure 3.51**.

● Valve spring length under load, **Figure 3.52**. Use spring tester ZTSE-2241.

4. Replace any spring assembly which fails visual or functional inspection.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 29

### CYLINDER HEAD (Reconditioning) - Continued

#### ● Inspection - Continued

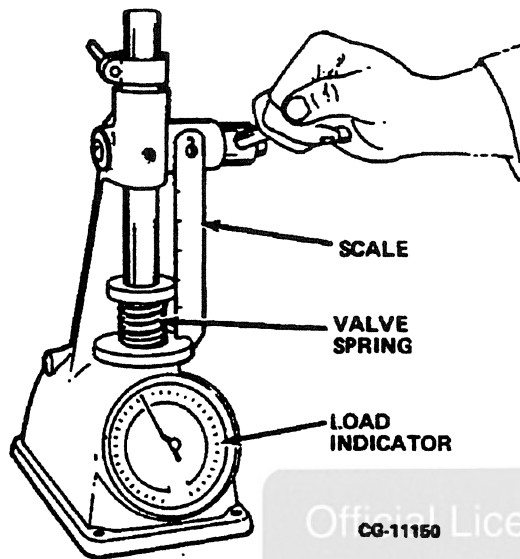


Figure 3.52. Checking Valve Spring Tension  
Using ZTSE-2241

#### ■ Valve Keepers

##### ● Cleaning

1. Clean valve keepers in a suitable solvent.

##### ● Inspection

1. Visually inspect inside and outside of keepers for wear.
2. Replace any worn keepers in pairs, as required.

#### ■ Valve Rotators

##### ● Cleaning

1. Clean rotators in a clean solvent.

##### ● Inspection

1. To properly test the rotator for function, a valve spring load must be applied to the rotator.

**NOTE:** The rotator must be lubricated with clean engine oil prior to testing.

2. Place the valve spring, with the rotators in the spring tester ZTSE-2241. Place a ball bearing between the rotator and ram of the spring tester.
3. Paint a reference line on the rotator.
4. Compress the valve spring rapidly and with even pressure and observe the rotator as it turns, (Refer to Figure 3.53.)
5. Replace any rotator which does NOT turn.

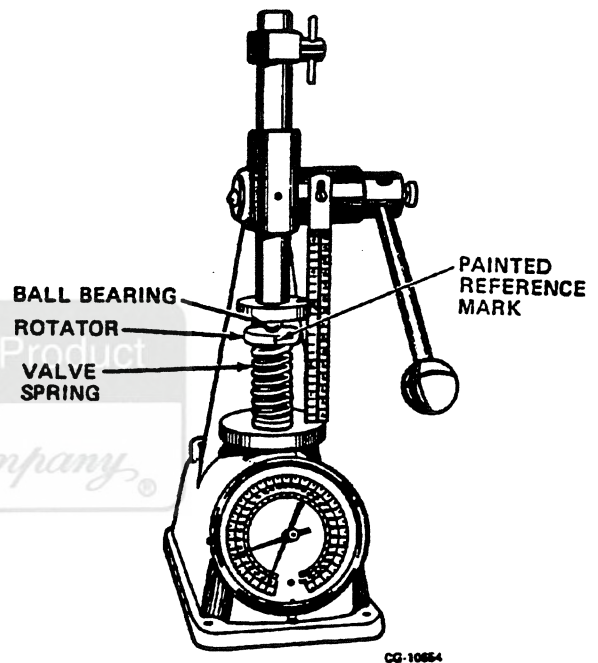
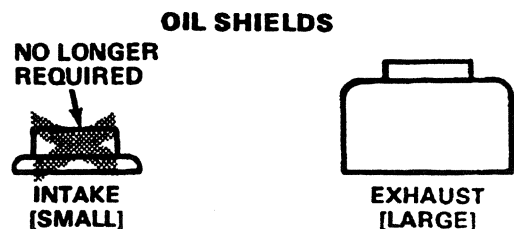


Figure 3.53. Testing Valve Rotator

#### ■ Oil Shield

##### ● Replace with new.



CG-14002

Figure 3.54. Oil Shield Identification  
[Early Production Engines]

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Reconditioning) - Continued

##### ■ Oil Shield - Continued

#### IMPORTANT

- EARLY PRODUCTION ENGINES -  
[S/N BELOW 520429]

THE VALVE STEM OIL SHIELDS USED ON THE INTAKE AND EXHAUST VALVES ARE DIFFERENT. THE INTAKE OIL SHIELD IS MUCH SMALLER THAN THE EXHAUST OIL SHIELD. DO NOT INTERCHANGE OIL SHIELDS BETWEEN THE INTAKE AND EXHAUST VALVES.

#### IMPORTANT

LATER PRODUCTION ENGINES [ABOVE S/N 520428] ARE NOT BUILT WITH THE INTAKE [SMALL] OIL SHIELD. SERVICE OF EARLY PRODUCTION ENGINES NO LONGER REQUIRES INSTALLATION OF THE INTAKE OIL SHIELD, IT MAY BE DELETED.



# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 31

### CYLINDER HEAD (Reconditioning) – Continued

#### ■ Reassembly

1. Clean valve faces and seats with a suitable cleaning solvent to remove dirt or foreign material. Blow dry all new and used components using filtered compressed air.

**NOTE: Guides MUST BE CLEAN!**

2. Lubricate the valve stems with clean engine oil.

3. Install intake and exhaust valves as follows:

a. Insert valves in head in their respective seats.

b. Install valve rotators (Figure 3.55).

c. **INTAKE ONLY:** Install new valve stem seals onto valve stem using installer tool ZTSE-4138 as follows:

● Hold valve on its seat with one hand and install the clear plastic valve seal guide (part of ZTSE-4138) as shown in Figure 3.55.

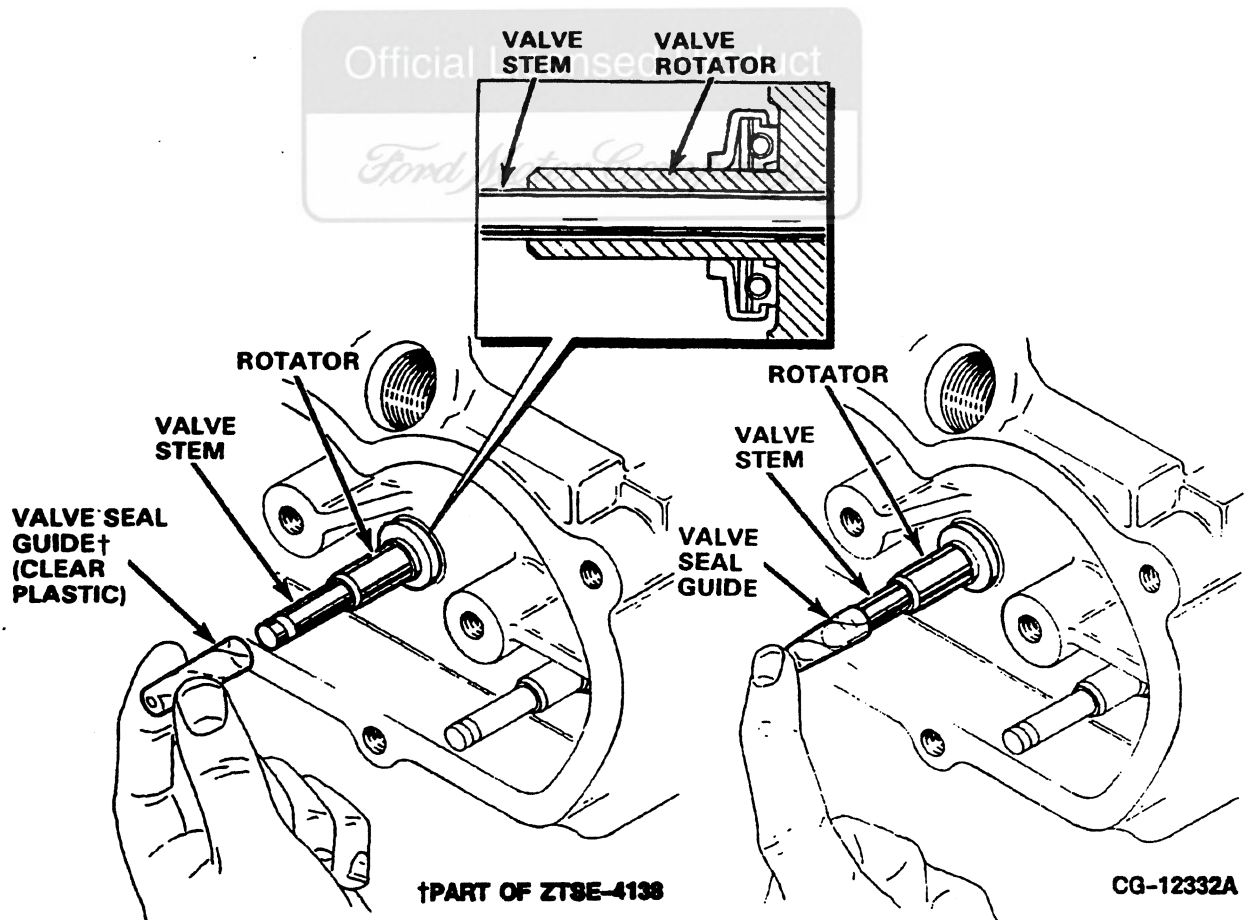


Figure 3.55. Valve Seal Guide Installation

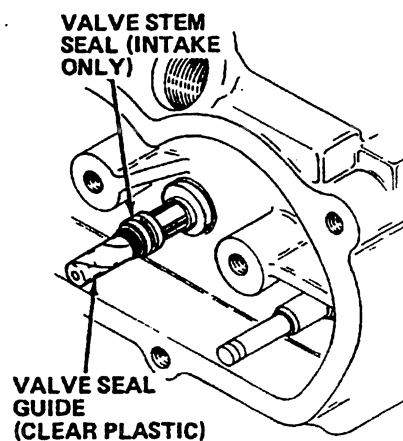
## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

#### CYLINDER HEAD (Reconditioning) - Continued

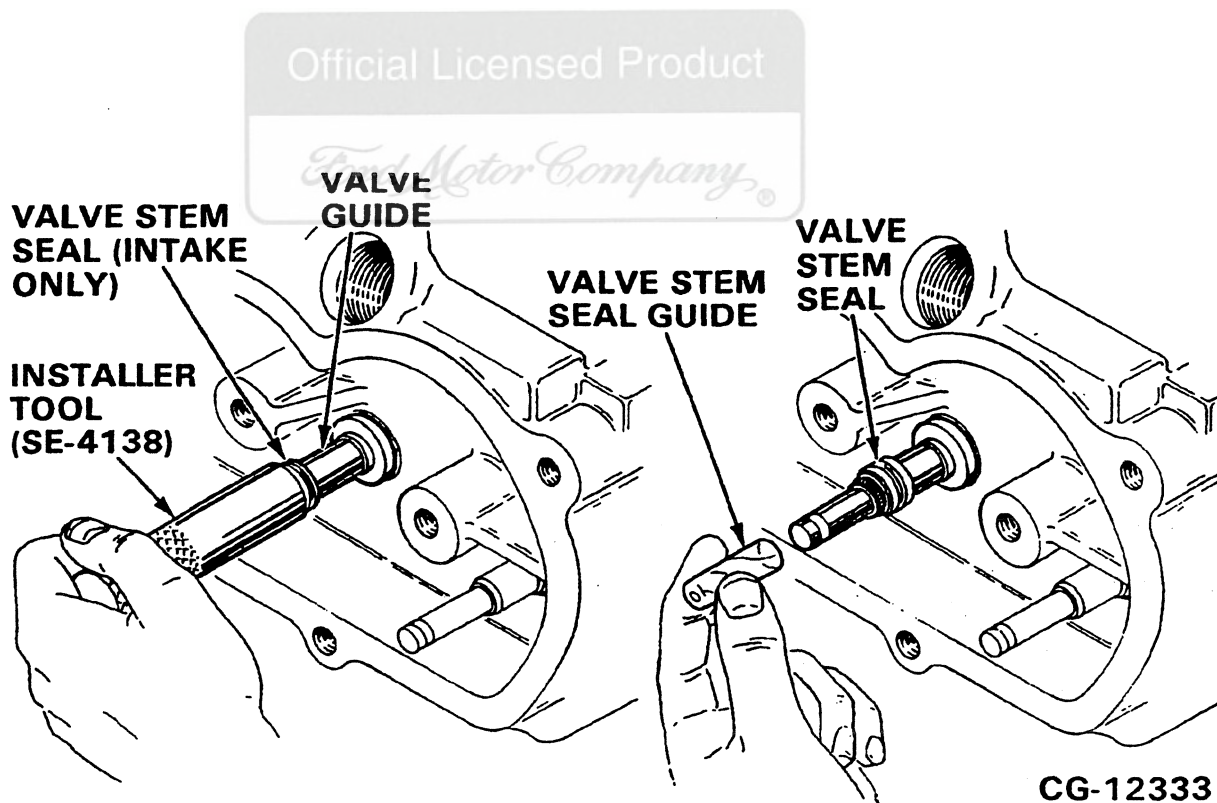
##### ■ Reassembly - Continued

- Install the seal by hand until it rests on the end of the valve guide (Figure 3.56).
- Use the seal installer ZTSE-4138 to align the seal over the end of the valve guide as shown in Figure 3.57. Apply only steady hand pressure until the seal bottoms squarely on the valve guide.
- Remove the clear plastic valve seat guide.



CG-11076

Figure 3.56. Valve Stem Seal Installed by Hand Over Valve Seal Guide



CG-12333

Figure 3.57. Installing Valve Stem Seal onto Valve Stem Using Installer Tool ZTSE-4138

# SERVICE MANUAL

## CYLINDER HEAD AND VALVES

Section 3  
Page 33

### CYLINDER HEAD (Reconditioning) - Continued

#### ■ Reassembly - Continued

4. Install spring assembly as shown (4, Figure 3.59).

5. Install a new exhaust valve oil shield into each valve spring retainer. Be sure each oil shield snaps into the retainer. Refer to Figure 3.58.

6. Install the exhaust valve spring retainer assembly (with oil shield) in the spring assembly and the intake valve spring retainer [without oil shield] into its respective spring assembly.

#### IMPORTANT

LATER PRODUCTION ENGINES ARE NOT BUILT WITH THE INTAKE [SMALL] OIL SHIELD. SERVICE OF EARLY PRODUCTION ENGINES NO LONGER REQUIRE INSTALLATION OF THE INTAKE OIL SHIELD. THE INTAKE OIL SHIELD MAY BE DELETED.

#### IMPORTANT

DO NOT TRY TO INSTALL THE LARGE EXHAUST OIL SHIELD ON THE INTAKE VALVE BECAUSE EXCESSIVE LUBE OIL CONSUMPTION CAN OCCUR, DUE TO INTERFERENCE OF THE OIL SHIELD WITH THE RUBBER STEM SEAL.

#### EXHAUST OIL SHIELD

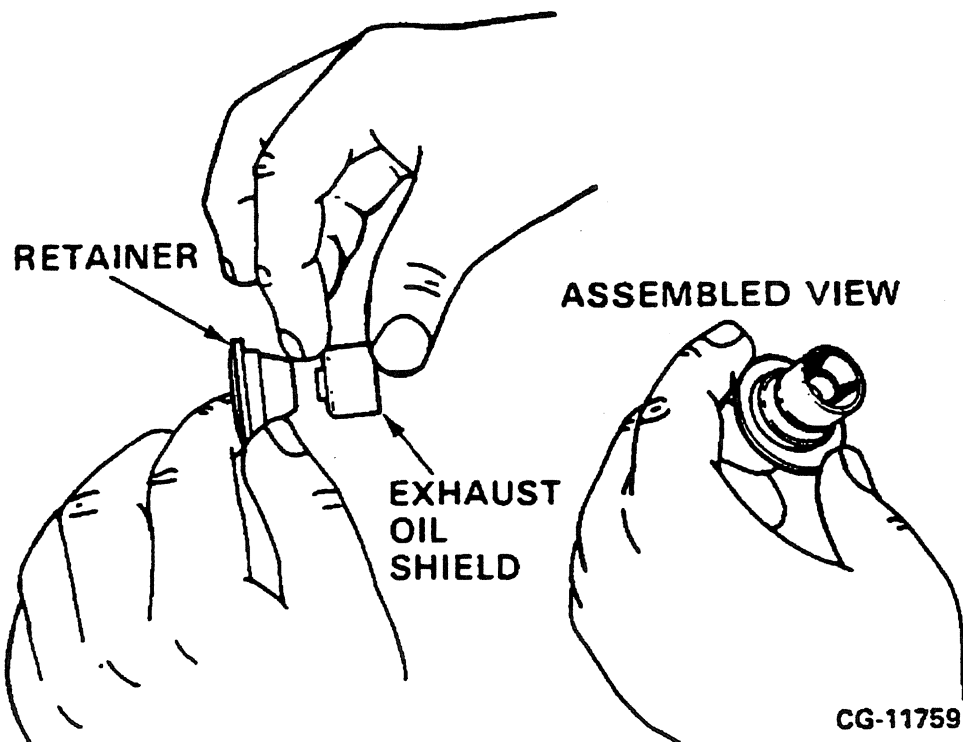


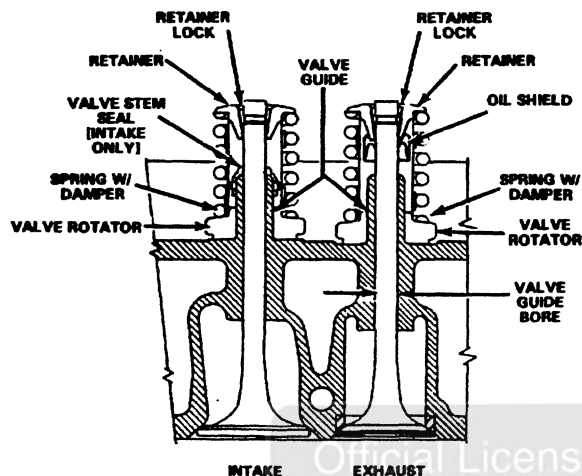
Figure 3.58. Installing Exhaust Oil Shield into Retainer

## SERVICE MANUAL

### CYLINDER HEAD AND VALVES

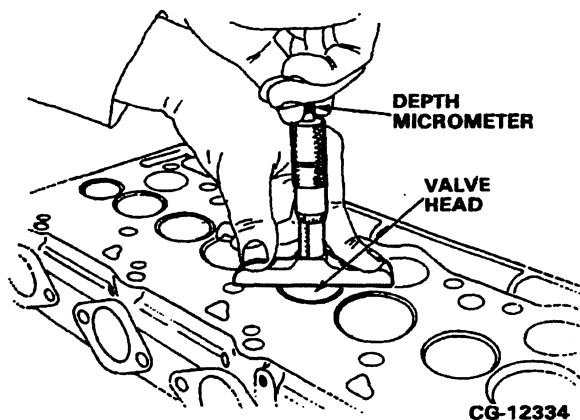
#### CYLINDER HEAD (Reconditioning) – Continued

#### ■ Reassembly – Continued



**Figure 3.59. Cross Section of Valve Assemblies in Cylinder Head**

7. Compress the valve springs using valve spring compressor ZTSE-1846. Install valve spring retainer locks (7, **Figure 3.59**). Be sure locks are correctly seated on all valves.



**Figure 3.60. Measuring Valve Head Recession**

8. After valve inspection, reconditioning/replacement and installation, measure valve head recession relative to deck (**Figure 3.60**) to confirm a good reconditioning job. Refer to "SPECIFICATIONS".

9. Install pre-combustion chambers as follows:

- Assure mating surface in head is free of debris.
- Apply clean grease to the mounting edge of the pre-combustion chamber(s) and install in heads.
- Tap lightly with a plastic hammer, if necessary.

**NOTE:** When installed, the pre-combustion chambers are acceptable with a .0025" protrusion above the cylinder head deck or a .0025" recession below the cylinder head deck.

10. Install fuel injection nozzles. (See Torque Data, Appendix, page 6.)

11. Install glow plugs using deep socket. (See Torque Data, Appendix, page 6.)

# SERVICE MANUAL

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

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\*Procedure used when camshaft is not removed from the crankcase.

# SERVICE MANUAL

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## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

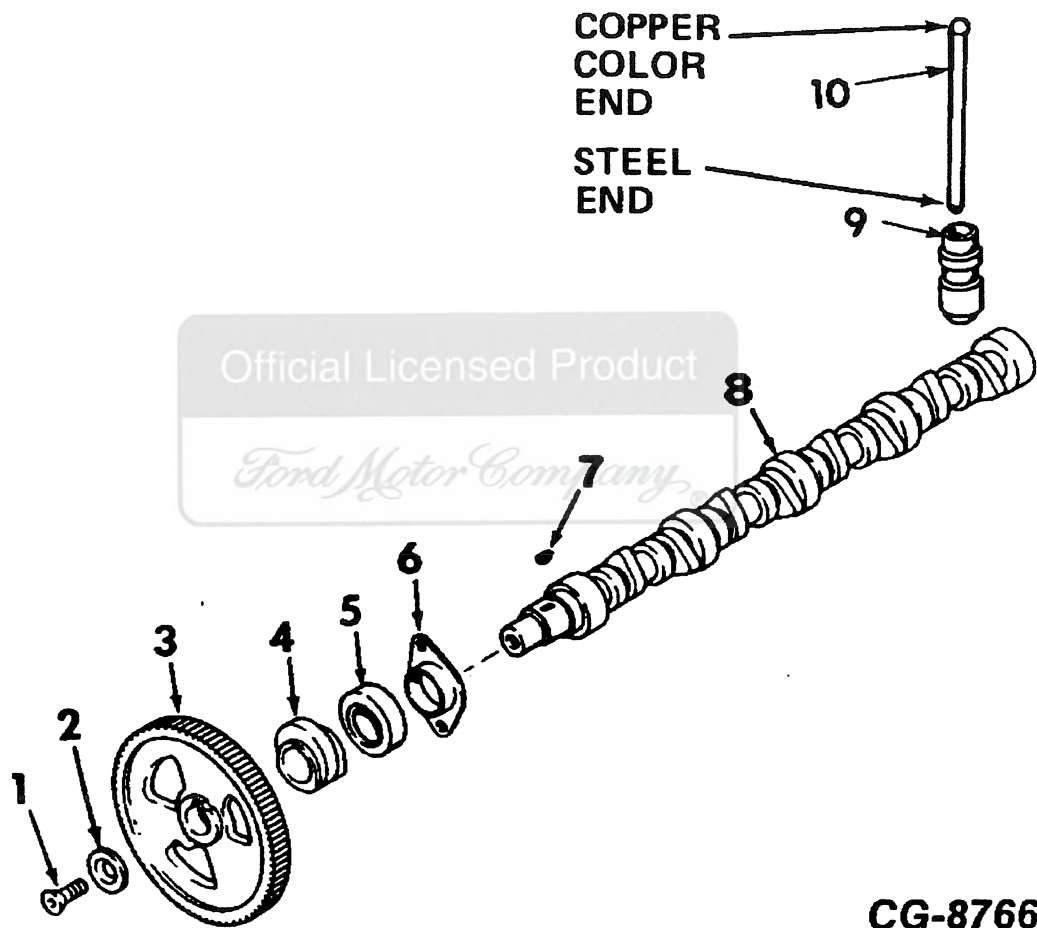


Figure 4.1. Camshaft and Related Components

- 1. Camshaft Screw
- 2. Camshaft Washer
- 3. Camshaft Gear
- 4. Fuel Pump Cam
- 5. Thrust Flange Spacer

- 6. Thrust Flange
- 7. Woodruff Key
- 8. Camshaft
- 9. Hydraulic Valve Lifter
- 10. Valve Push Rod



## SERVICE MANUAL

### VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

#### SPECIFICATIONS

##### CAMSHAFT

Bearing Journal Diameter (All Journals).....	2.0900"–2.1000" (53.31–53.34 mm)
Bearing (Bushing) Diameter.....	2.1015"–2.1025" (53.37–53.40 mm)
Journal/Bushing Running Clearance.....	0.0015"–0.0035" (0.038–0.089 mm)
Shaft End Play.....	0.002"–0.009" (0.025–0.228 mm)
Timing Gear Backlash.....	0.0015"–0.013" (0.038–0.330 mm)
Lobe Surface Finish.....	12 RMS
Maximum Permissible Cam Lobe Wear.....	0.020" (0.51 mm)
Journal Surface Finish.....	16 RMS
Lobe Taper.....	.0002" (0.005 mm)
Camshaft Thrust Flange Thickness.....	0.4305"–0.4355" (10.93–11.06 mm)
Camshaft Lift	
Intake .....	0.2535" (6.44 mm) Max.
Exhaust .....	0.25308" (6.43 mm) Max.
Valve Timing No. 1 Cylinder	
(Top of Ramp)	
Intake Open.....	17.2° BTDC
Closed.....	42.8° ABDC
Exhaust Open.....	51.2° BBDC
Closed.....	20.8° ATDC

##### HYDRAULIC VALVE LIFTERS

Diameter.....	0.9209"–0.9217" (23.391–23.411 mm)
Bore Diameter in Block.....	0.9228"–0.9243" (23.439–23.477 mm)
Clearance in Bore.....	0.0011"–0.0034" (0.027–0.086 mm)
Bleed-down Rate.....	20–110 Sec. for 0.125" Travel*

\*Time required for plunger to move 0.125" under 50 lbs load with **test fluid at room temperature.**

Type..... Roller Follower

##### PUSH ROD

Run Out (Max. TIR)..... 0.015" Max.

#### SPECIAL TORQUES

Camshaft Screw..... 15 lbf–ft (20 N.m)

#### SPECIAL SERVICE TOOLS

<u>Tool No.</u>	<u>Description</u>
ZTSE-1893	Hydraulic Valve Lifter Tester
ZTSE-1900-69	Damper, Crankshaft and Camshaft Gear Installer
ZTSE-2295-69	Damper, Crankshaft and Camshaft Gear Remover
ZTSE-1880-D	Camshaft Remover and Installer
ZTSE-1897-D	Camshaft Bushing Remover and Installer Set
SE-4156	Fuel Pump Cam Remover and Installer
ZTSE-1879	Slide Hammer Set
SE-1879-5	5/8 in. – 18 Female to 1 in. – 14 Female Adapter

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### HYDRAULIC VALVE LIFTER ROLLER TYPE

#### ■ Operation

Oil from oil gallery, is supplied to the lifter through a hole in the side of the lifter body which indexes with a groove and hole in the lifter plunger. Oil is then metered past the oil metering valve in the lifter, through the push-rods to the rocker arms.

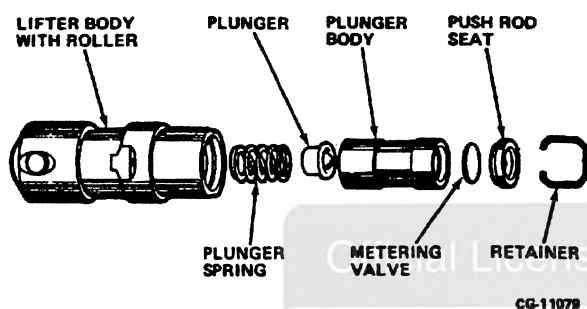


Figure 4.2. Hydraulic Valve Lifter

When the lifter begins to roll up the cam lobe, the check valve is held against its seat in the plunger by the check valve spring which traps the oil in the base of the lifter body below the plunger. The plunger and lifter body then raise as a unit, pushing up the push-rod to open the valve. The force of the valve spring which is exerted on the plunger through the rocker arm and push-rod causes a slight amount of leakage between the plunger and lifter body. This "leak-down" allows a slow escape of trapped oil in the base of the lifter body. As the lifter rides down the other side of the cam lobe and reaches the base circle or "valve closed" position, the plunger spring quickly moves the plunger back (up) to its original position. This movement causes the check valve to open against the check valve spring and oil from which the plunger is drawn into the base of the lifter. This restores the lifter to zero lash.

**NOTE:** Valve lifters and push rods should be kept in order so they can be re-installed in their original position. Good oil quality and following the recommended oil drain intervals are the key to long valve train life.

#### ■ Removal

Remove the following prior to servicing the valve train, camshaft, cam followers and push rods: (Refer to the appropriate manual section).

Injection Lines	Front Plate
Injection Pump	Valve Covers
Intake Manifold	Valve Lever Assy.
Valley Pan and Gasket Assembly	Engine Mounted Fuel Supply Pump
Injection Pump Gear	Fuel Filter Assy.
Water Pump	

1. Remove the valve lifter guide retainer (Figure 4.3), by removing the three bolts and washers which fasten it to the block.

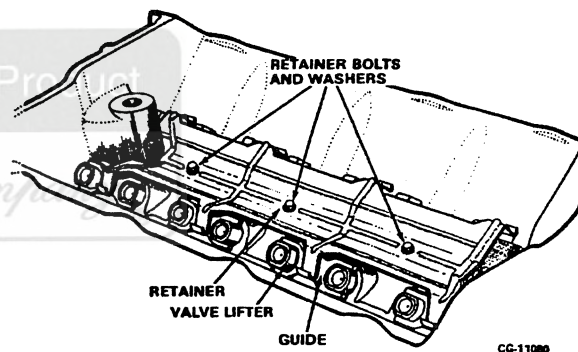


Figure 4.3. Valve Lifter Guide Retainer Removal

2. Remove valve lifter guides (Figure 4.4).

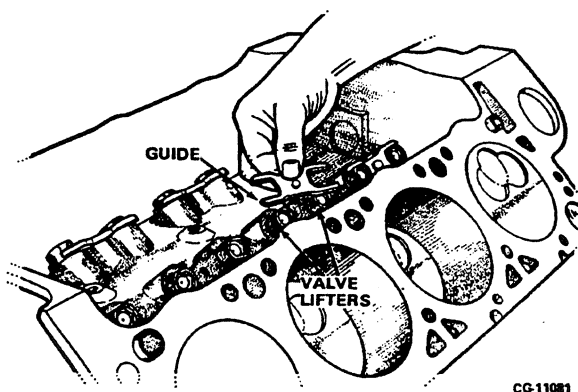


Figure 4.4 Valve Lifter Guide Removal.

## SERVICE MANUAL

### VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

#### HYDRAULIC VALVE LIFTERS

##### ■ Removal - Continued

3. Remove hydraulic valve lifters (1, Figure 4.5).

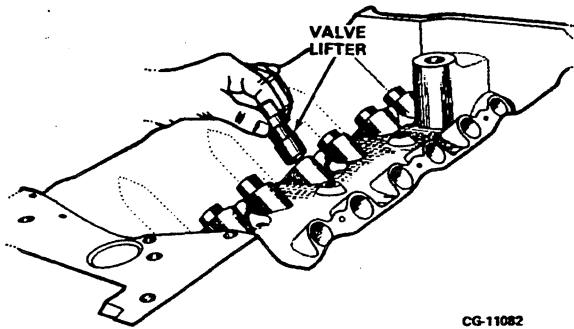


Figure 4.5. Valve Lifter Removal

##### IMPORTANT

IDENTIFY HYDRAULIC VALVE LIFTER POSITION AS TO CYLINDER HEAD AND PORT IN ENGINE BLOCK AS WELL AS DIRECTION OF ROTATION SO THEY CAN BE REINSTALLED IN THEIR ORIGINAL POSITION.

**NOTE:** As a general rule, hydraulic valve lifters should be left alone when they are functioning satisfactorily and the valve train remains quiet.

##### ■ Leakdown Test

Used to determine whether the leakage past the plunger and cylinder is correct and if the check valve is functioning properly.

1. Use the ZTSE-1893 Leakdown Tester, Figure 4.6, for checking the leak down rate. Follow instructions which accompany the tester.
2. Leakdown or bleed-down rate is the time in seconds for the plunger to move a specified distance of its travel while under a 50 lb. load. Refer to "SPECIFICATIONS".

##### IMPORTANT

USE TEST FLUID SPECIFIED BY THE TOOL MANUFACTURER WITH FLUID AT ROOM TEMPERATURE.

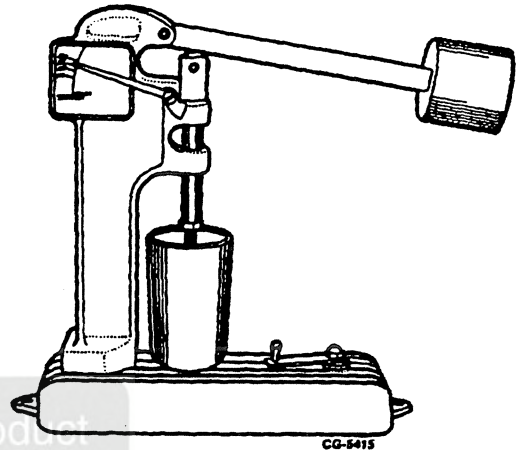


Figure 4.6 Hydraulic Valve Lifter Tester  
ZTSE-1893

##### ■ Disassembly (Refer to Figure 4.2)

1. Remove the push rod seat retainer using a small screwdriver.
2. Remove the push rod seat and metering valve.
3. Remove the plunger body and plunger spring.

##### ■ Cleaning and Inspection

1. Immerse all parts in clean solvent. Remove and dry.
2. Visually inspect all disassembled parts for nicks, burrs or scoring. If signs of damage are visible, replace the entire hydraulic cam follower.
3. **IMPORTANT!** Check the rollers as follows:
  - a. While pushing on the roller in normal direction of load, examine for free rotation of roller.
  - b. Visually inspect roller for pits or roughness.
  - c. If a roller fails any one of the preceding inspection criteria **YOU MUST INSPECT THE CAMSHAFT LOBES FOR DAMAGE.**

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### HYDRAULIC VALVE LIFTERS

#### ■ Cleaning and Inspection - Continued

#### IMPORTANT

THE ROLLER ON THE VALVE LIFTER IS NOT FLAT BUT ACTUALLY CROWNED BY DESIGN. THEREFORE, A NORMAL WEAR PATTERN WILL NOT TYPICALLY BE COMPLETELY ACROSS THE ROLLER.

#### Reassembly (Refer to Figure 4.2)

1. Coat all hydraulic valve lifter parts with clean engine oil.
2. Install plunger spring and plunger into lifter body.

3. Install metering valve and push rod seat into lifter, install retaining ring.

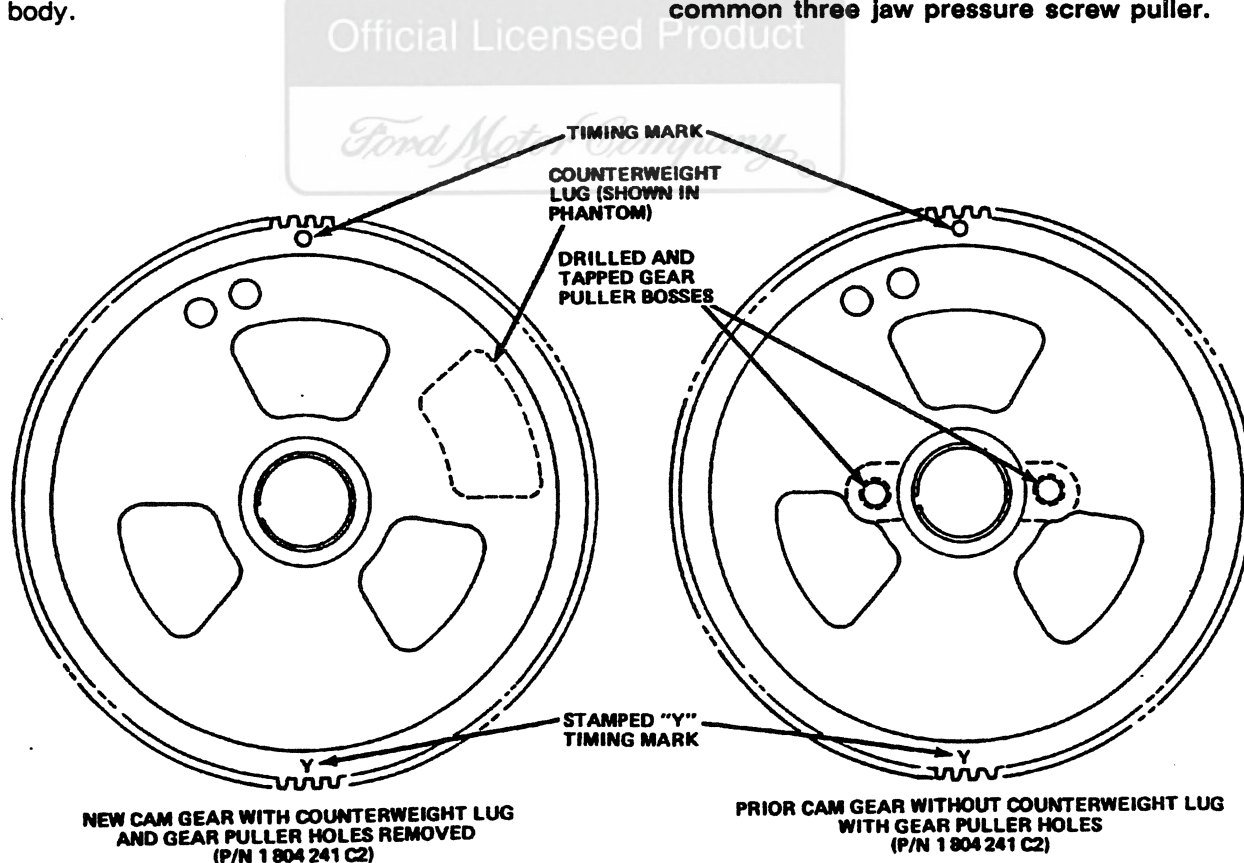
**NOTE:** After reassembly, perform a leakdown test to assure that leakage past the plunger and cylinder is correct and to assure that the check valve is functioning properly.

### CAMSHAFT ASSEMBLY

#### ■ New Camshaft Assembly Balance

Improved camshaft assembly balance is achieved by the addition of a counterweight lug to the inboard side of the cam gear, as well as elimination of the drilled & tapped gear puller bosses. Refer to Figure 4.7.

**NOTE:** Gear puller holes and related bosses were eliminated to facilitate machining and camshaft assembly balance. Cam gear removal is now accomplished using any common three jaw pressure screw puller.



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Figure 4.7. Cam Gear Comparison [Weighted vs. Unweighted]



## SERVICE MANUAL

### VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

#### CAMSHAFT ASSEMBLY - Continued

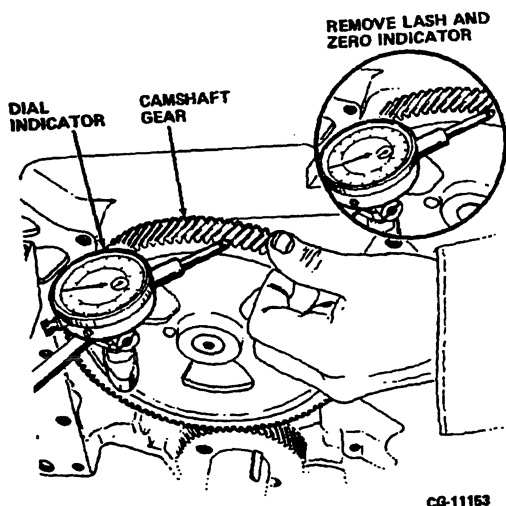
##### ■ Removal

1. Prior to camshaft removal, mount dial indicator on front of engine and check and record camshaft gear-to-crankshaft gear backlash (**Figure 4.8**). If backlash exceeds specified limits (see **SPECIFICATIONS**) timing gears should be replaced.

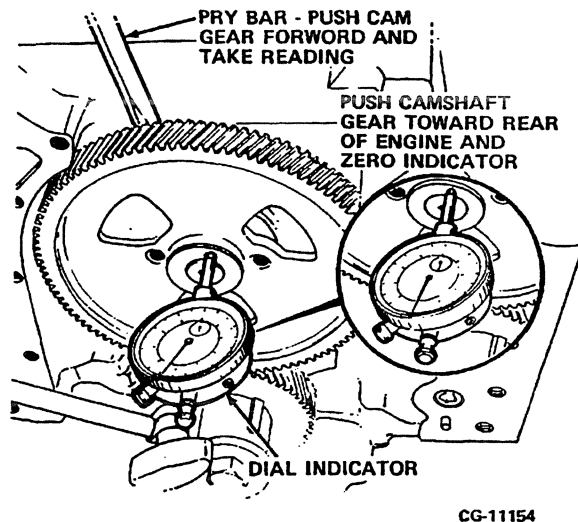
- Position the dial indicator tip @ a gear tooth and remove lash.
- Zero the dial indicator.
- Move the gear by hand and read the indicator. Record backlash.

2. Reposition the dial indicator and check camshaft end play (**Figure 4.9**) as follows:

- Push the camshaft toward the rear of the engine.
- Zero the dial indicator.
- Position a large screwdriver between the camshaft gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with the specifications.
- Remove the dial indicator.
- If end play exceeds specified limits, (see "**SPECIFICATIONS**"), replace the camshaft thrust plate.

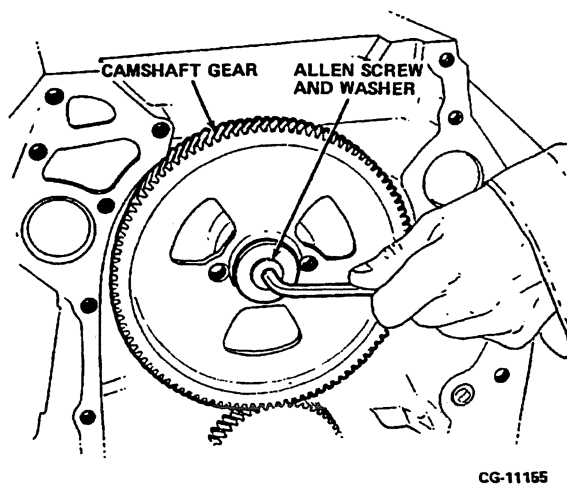


**Figure 4.8. Camshaft Gear-to-Crankshaft Gear Backlash Measurement**



**Figure 4.9. Checking Camshaft End Play**

3. Remove camshaft Allen screw and washer, **Figure 4.10**.



**Figure 4.10. Removing Camshaft Allen Screw [Earlier Cam Gear Shown]**

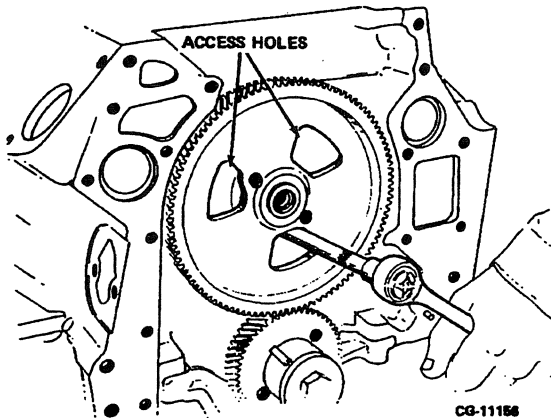


## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### CAMSHAFT ASSEMBLY – Continued

#### ■ Removal – Continued

4. Remove camshaft thrust plate bolts through the access holes, **Figure 4.11**.

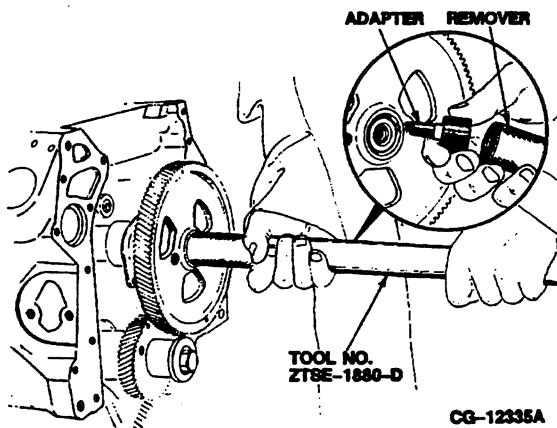


**Figure 4.11. Removing Camshaft Thrust Bolts**  
[Earlier Cam Gear Shown]

5. With the camshaft thrust plate bolts and camshaft Allen screw removed, use ZTSE-1880-D **Figure 4.12** to remove the camshaft assembly. When the remover and adapter are threaded into the camshaft, proper leverage is provided for easy camshaft assembly removal.

**NOTE:** ZTSE-1880-D consists of:

- ZTSE-1880-1 Camshaft Remover and Installer
- ZTSE-1880-2 Adapter



**Figure 4.12. Removing Camshaft Assembly**  
Tool No. ZTSE-1880-D  
[Earlier Cam Gear Shown]

#### ■ Cleaning and Inspection

1. Wash the camshaft in cleaning solvent with a soft brush.
2. Visually inspect the camshaft. If any lobes are scuffed, scored or cracked, replace the camshaft.

**NOTE:** The 7.3L utilizes a hydraulic valve lifter and therefore, a lifter guide is needed to maintain proper roller to cam lobe orientation. Normal clearance between the valve lifter and guide allows slight tracking of the roller across the cam lobe.

- This tracking of the valve lifter is a normal characteristic as the roller accelerates and decelerates during typical engine operation.
- Consequently, a typical wear pattern on the cam lobes will exhibit tracks from side to side and have wide and narrow areas from the loading and unloading of the follower.
- The visual wear pattern (tracking) is normal and does not require camshaft replacement.

3. Beyond visual inspection, evaluate camshaft journal and lobe condition using a micrometer as follows:

- a. Inspect the camshaft journals for wear. Using a micrometer, measure the camshaft journal diameter (see "SPECIFICATIONS"). If journals are worn beyond limits, replace the camshaft.

- b. Check camshaft lobe wear using a micrometer as follows:

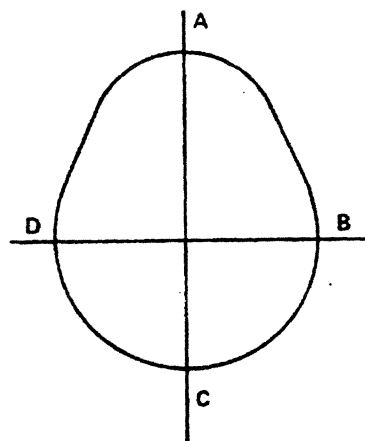
- Measure across (A-C) and across (B-D). Refer to **Figure 4.13**.
- Subtract (B-D) from (A-C). This will give cam lobe lift. (See "SPECIFICATIONS").
- Replace camshaft when cam lobe wear exceeds "SPECIFICATIONS".

# SERVICE MANUAL

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### CAMSHAFT ASSEMBLY - Continued

#### ■ Cleaning and Inspection - Continued



CG-11132

#### 4.13. Points of Measurement to Determine Cam Lobe Wear

4. Visually inspect the thrust flange for wear, cracks or distortion. Use a micrometer to measure thrust flange thickness. (See "SPECIFICATIONS"). Replace the thrust plate if worn or damaged.

5. Visually inspect the camshaft drive gear for worn or damaged teeth. Replace the gear, if required.

### IMPORTANT

**WHEN SERVICING THE CAMSHAFT BUSHINGS, THE CRANKSHAFT AND MAIN BEARINGS MUST BE REMOVED FROM THE CRANKCASE TO AVOID DEBRIS CONTAMINATION. REFER TO SECTION 6 FOR DETAILED INSTRUCTIONS.**

#### ■ Bushing Inspection

6. Inspect the five camshaft bushings for wear and proper running clearance (see SPECIFICATIONS). If limits are exceeded, replace with new bushings using camshaft bushing remover and installer set SE-1897-D.

#### ■ Bushing Removal and Installation

NOTE: ZTSE-1897-D includes: (See IMPORTANT)

- Pilot bar (ZTSE-1897-1)
- "C" washer (ZTSE-1897-2)
- Adapters (ZTSE-1897-7) (2 required)

### IMPORTANT

**USE WITH ZTSE-1879 SLIDE HAMMER SET AND 5/8 IN. - 18 FEMALE TO 1 IN. - 14 FEMALE ADAPTER (SE-1879-5)**

The bushings are interchangeable from one bore to another except for the front bushing which is wider than the others.

Bearing Position	Bearing Width
Front (#1)	.780"
Intermediates & Rear (#2-5)	.645"

#### ■ Removal (Refer to Figure 4.14)

1. Use the two adapters (SE-1897-7), "C" washer (ZTSE-1897-2), pilot bar (ZTSE-1897-1) and slide hammer set (ZTSE-1879), as follows to remove the camshaft bushings.

- a. Position one adapter, in the bushing to be removed, with the flange toward the rear of the crankcase.
- b. Position the second adapter in the bushing bore adjacent to the bushing that is to be removed, with the flange toward the rear of the crankcase.
- c. Install the pilot bar through the adapters and lock the pilot bar, using the "C" washer, at the adapter installed in the bearing which is to be removed.
- d. Using the second adapter (step 1b) as a pilot, install the slide hammer and pull the bushing out of its bore.

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### CAMSHAFT ASSEMBLY – Continued

#### ■ Removal (Refer to Figure 4.14) – Continued

2. Repeat steps 1a – 1d for each bushing to be removed.

**NOTE:** Always hold the adapter firmly against the bearing being removed to avoid damage. With the bushing removed, inspect the bushing bore in crankcase for burrs or other roughness which may damage bushings during installation.

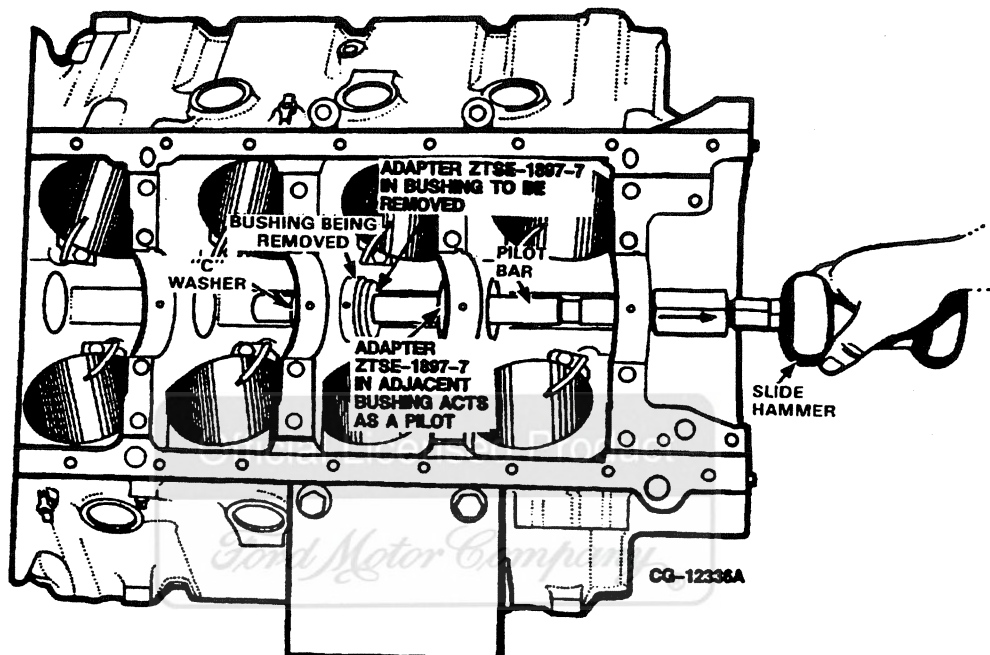


Figure 4.14. Camshaft Bushing Removal (No. 3 Bushing Removal Shown)

#### ■ Installation (Refer to Figure 4.15)

1. Lubricate the new camshaft bushing and crankcase bore with clean engine oil.
2. Position one adapter (ZTSE-1897-7) in the camshaft bushing bore adjacent to the bushing to be installed, with the flange toward the rear of the crankcase.
3. Position the new bushing on the other adapter (ZTSE-1897-7).

**NOTE:** Chamfered side of bushings face the rear of the engine.

4. Place the adapter, with bushing, in the bore into which it is to be installed.

5. Insert the pilot bar through the camshaft bushing bores with adapters and lock the pilot bar, using the "C" washer in front of the adapter with the bushing to be installed.

#### IMPORTANT

**ALIGN THE OIL HOLES IN THE BUSHING AND CRANKCASE PRIOR TO DRIVING THE BUSHING INTO THE BORE.**

6. Using the slide hammer, push the bushing into place.
7. Repeat steps 1 through 6 for each bushing to be installed.

**NOTE:** Always hold the adapter firmly against the bearing being installed to avoid damage.

## SERVICE MANUAL

### VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

#### CAMSHAFT ASSEMBLY - Continued

#### ■ Installation (Refer to Figure 4.15) - Continued

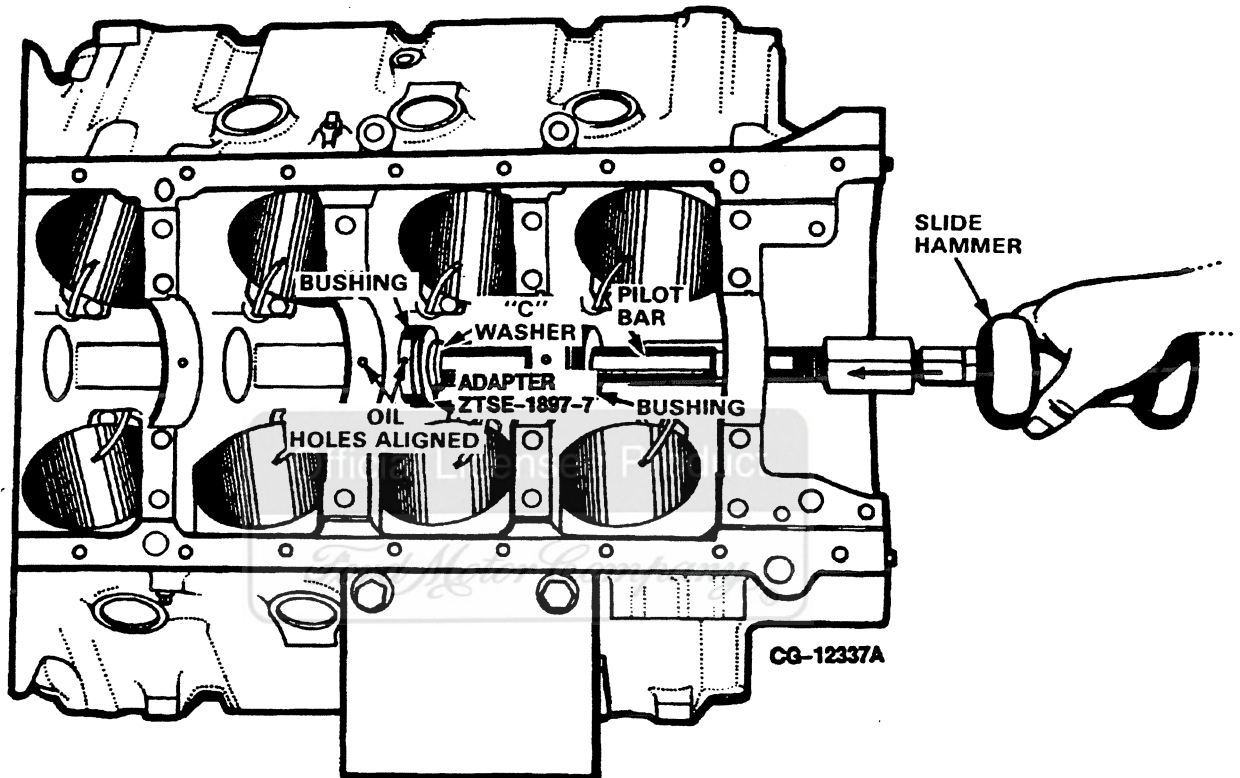


Figure 4.15. Camshaft Bushing Installation  
(No. 3 Bushing Installation Shown)

#### ■ Fuel Pump Cam Removal

**NOTE:** The camshaft gear, spacer and fuel pump cam eccentric can be removed without removing the camshaft. This is accomplished as follows:

1. Visually inspect the fuel pump cam for wear or scoring, prior to removal.
2. Remove the camshaft Allen screw, Figure 4.10.
3. Remove the prior camshaft gear with gear puller holes using ZTSE-2295-69 Puller, Figure 4.16A.
4. Attach the vibration damper, crank and cam gear remover ZTSE-2295-69 (Figure 4.16A) to the cam gear using two bolts threaded through the long slots in the puller plate. Use the small shaft protector and position it on the end of the cam shaft. Turn the forcing screw (Figure 4.16A) to remove the gear.
5. The new cam gear w/counterweight lug and gear puller holes remover can not use the current tool ZTSE-2295-69. The new gear can be removed using any common three-jaw pressure screw puller [which has a spreader for the jaws]. Refer to Figure 4.16B.



# SERVICE MANUAL

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## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS CAMSHAFT ASSEMBLY - Continued

### ■ Fuel Pump Cam Removal - Continued

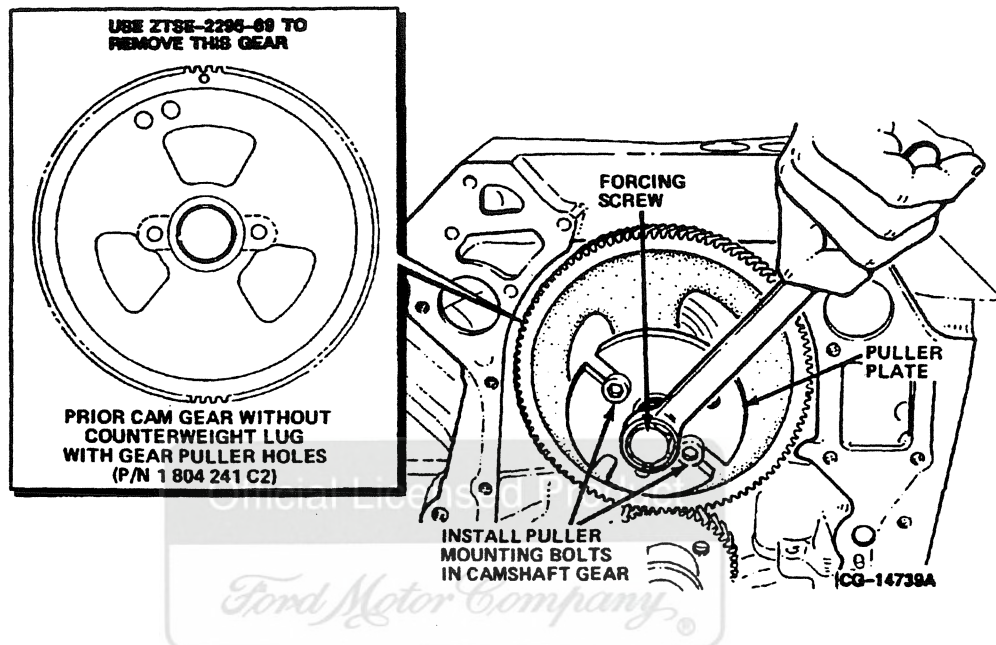


Figure 4.16A. Removing Camshaft Gear Using ZTSE-2295-69

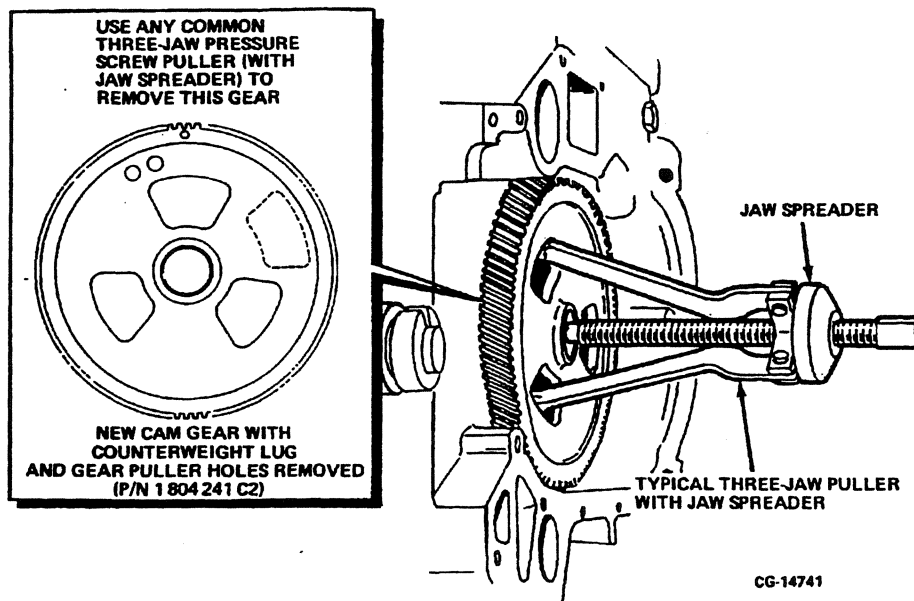


Figure 4.16B. Removing New Camshaft Gear Using Typical Three Jaw Puller.



# SERVICE MANUAL

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### CAMSHAFT ASSEMBLY – Continued

#### ■ Fuel Pump Cam Removal – Continued

6. With the gear removed, remove the woodruff key on the camshaft, near the fuel pump cam using SE-4156 Puller (Figure 4.17).

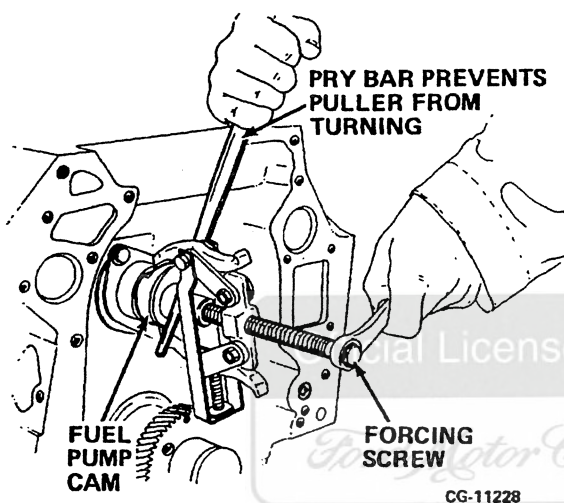


Figure 4.17. Removing Fuel Pump Cam Using SE-4156 Puller

7. Remove thrust flange spacer using SE-4156 Puller (Figure 4.18).

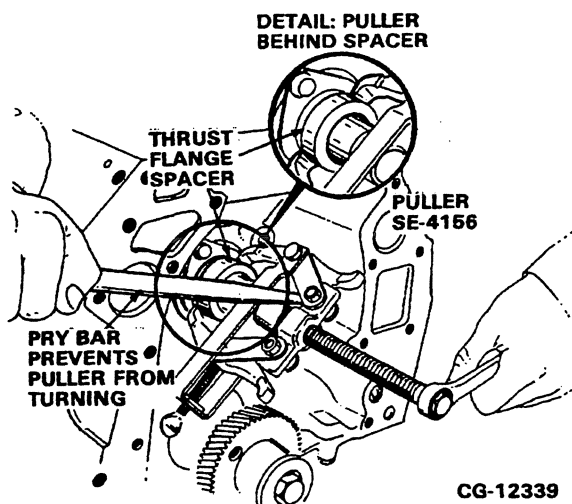


Figure 4.18. Removing Thrust Flange Spacer

#### ■ Fuel Pump Cam Cleaning and Inspection

1. Wash the fuel cam in a clean solvent and clean with a soft brush.
2. Replace the cam if nicked, scored or otherwise damaged.

**NOTE:** If the fuel pump cam is replaced, replace the fuel supply pump. Refer to Section 9.

#### ■ Fuel Pump Cam Installation

**NOTE:** If the camshaft gear, spacer and fuel pump cam were removed without removing the camshaft as described under “Fuel Pump Cam Removal”, they must be reinstalled as follows:

1. Coat spacer, fuel pump cam and camshaft gear with clean engine oil.
2. Install thrust flange spacer against thrust flange on camshaft using the sleeve (part of SE-4156) in conjunction with ZTSE-1900-69 “Damper/Crank/Cam Gear Installer”. Refer to Figure 4.19.

**NOTE:** A thrust bearing is used under the forcing screw to reduce friction.

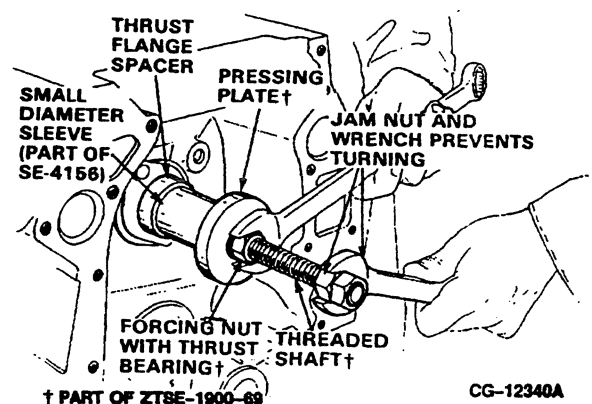


Figure 4.19. Installing Thrust Flange Spacer

## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### CAMSHAFT ASSEMBLY - Continued

#### ■ Fuel Pump Cam Installation - Continued

#### IMPORTANT

**INSTALL WOODRUFF KEY (7, FIGURE 4.1) IN CAMSHAFT PRIOR TO INSTALLING FUEL PUMP CAM. THIS ASSURES PROPER ORIENTATION OF CAM.**

3. Install fuel pump cam lobe against thrust flange spacer on camshaft by aligning keyways on fuel pump cam lobe with key in camshaft. Use ZTSE-1900-69 "Damper/Crank/Cam Gear Installer" and sleeve (part of SE-4156) in a manner similar to steps 1 and 2.

4. Install camshaft gear over woodruff key, against fuel pump cam lobe on camshaft using ZTSE-1900-69 with large diameter sleeve and thrust bearing as shown in Figure 4.20.

**NOTE:** Assemble with timing marks on the front side of the gear. Align timing marks with crankshaft gear marks. Refer to Figure 4.20.

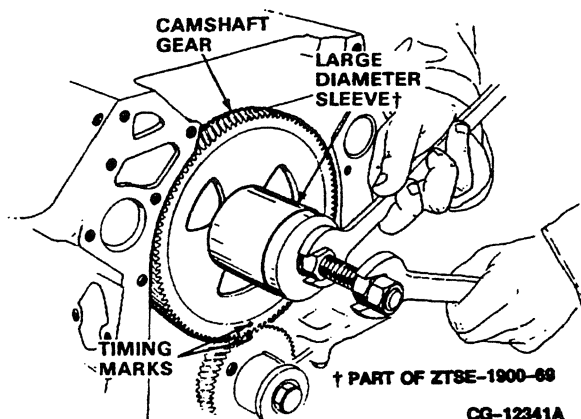


Figure 4.20. Cam Gear Installation and Timing Mark Alignment

5. Install camshaft washer (2, Figure 4.1) and screw (1, Figure 4.1) then tighten to specified torque. (See Special Torques, Page 2.)

### CAMSHAFT ASSEMBLY

#### ■ Installation

1. Coat the fuel pump cam, camshaft lobes and bearing surfaces with clean engine oil.

2. Install the camshaft with thrust flange, spacer, fuel pump cam and camshaft gear installed on shaft. Use Camshaft Remover and Installer Tool (ZTSE-1880-D), refer to Figure 4.12. Align timing marks with crankshaft gear marks, refer to Figure 4.21.

3. Install the two thrust flange bolts and lock washers, working through the holes in the camshaft gear. See appendix "Standard Nut and Bolt Torque Chart", for proper torque.

4. Install camshaft screw and lock washer (Figure 4.21) and tighten to specified special torque. (See Special Torques, page 2.)

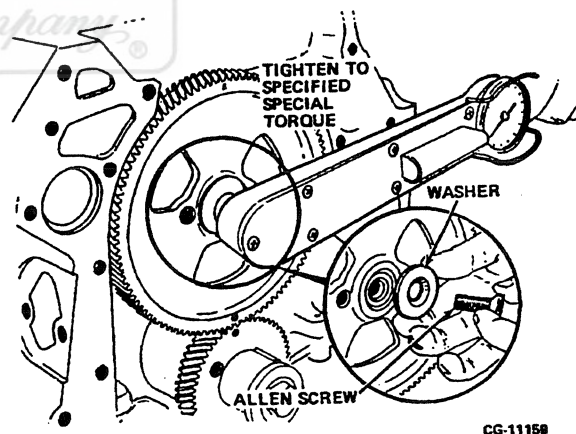


Figure 4.21. Camshaft Screw Installation

#### IMPORTANT

**CHECK CAMSHAFT END PLAY AGAIN; IF NEW PARTS ARE INSTALLED, REFER TO FIGURE 4.8 AND CORRESPONDING TEXT FOR THE PROCEDURE.**

## SERVICE MANUAL

### VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

#### CAMSHAFT ASSEMBLY - Continued

#### VALVE TRAIN

##### PUSH RODS

###### ■ Cleaning and Inspection

**NOTE:** The push rods are hollow and serve as oil galleries to lubricate each individual rocker arm assembly.

1. Thoroughly clean each push rod using a suitable solvent and dry using filtered compressed air.
2. Visually inspect each rod for wear and deposits which may restrict the flow of oil into the valve lever assemblies. Replace as required.
3. Check all push rods for straightness by rolling on a flat surface, Figure 4.22.

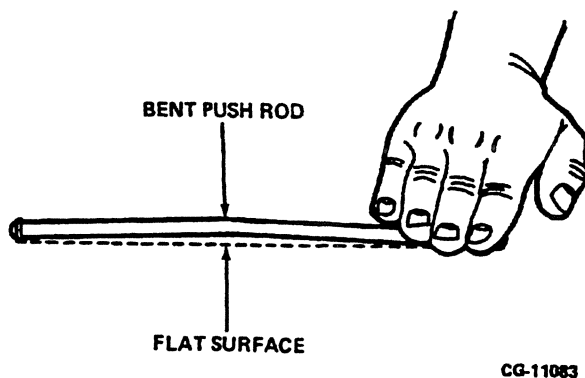


Figure 4.22. Checking Push Rod for Straightness

4. Check push rod runout. If "SPECIFICATIONS" are exceeded or if straightness is questionable, replace the rod.

###### ■ Reassembly

**NOTE:** Assure all parts are clean prior to reassembly and lubricate all parts with clean engine oil.

1. Install hydraulic valve lifters (4, Figure 4.23) in their respective bores in the cylinder block.
2. Install valve lifter guides (3, Figure 4.23) over the hydraulic valve lifters.

#### IMPORTANT

**INSTALL VALVE LIFTER GUIDES WITH RAISED BUMP UP. REFER TO FIGURE 4.24.**

3. Install guide retainer (2, Figure 4.23) and fasten the 3 guide retainer bolts and washers (1, Figure 4.23).
4. Insert the valve push rods (5, Figure 4.23) in their respective positions. Install with copper color end up, to assure the "hard" end of the push rod mates with the valve lever.
5. Reinstall all other removed items. See appropriate manual section for detailed assembly procedure

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## VALVE TRAIN: CAMSHAFT, HYDRAULIC VALVE LIFTERS AND PUSH RODS

### VALVE TRAIN – Continued

#### ■ Reassembly – Continued

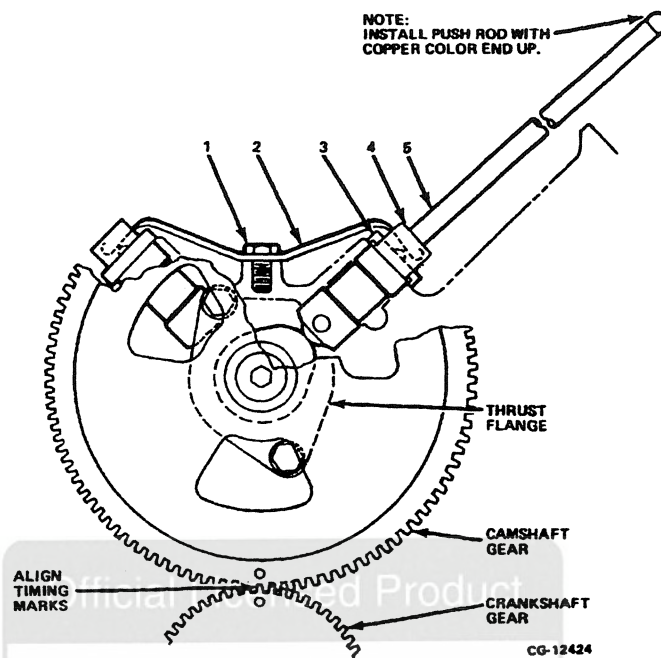


Figure 4.23. Valve Train – Assembled View

- |                                 |                           |
|---------------------------------|---------------------------|
| 1. Guide Retainer Bolt w/Washer | 4. Hydraulic Valve Lifter |
| 2. Guide Retainer               | 5. Push Rod               |
| 3. Valve Lifter Guide           |                           |

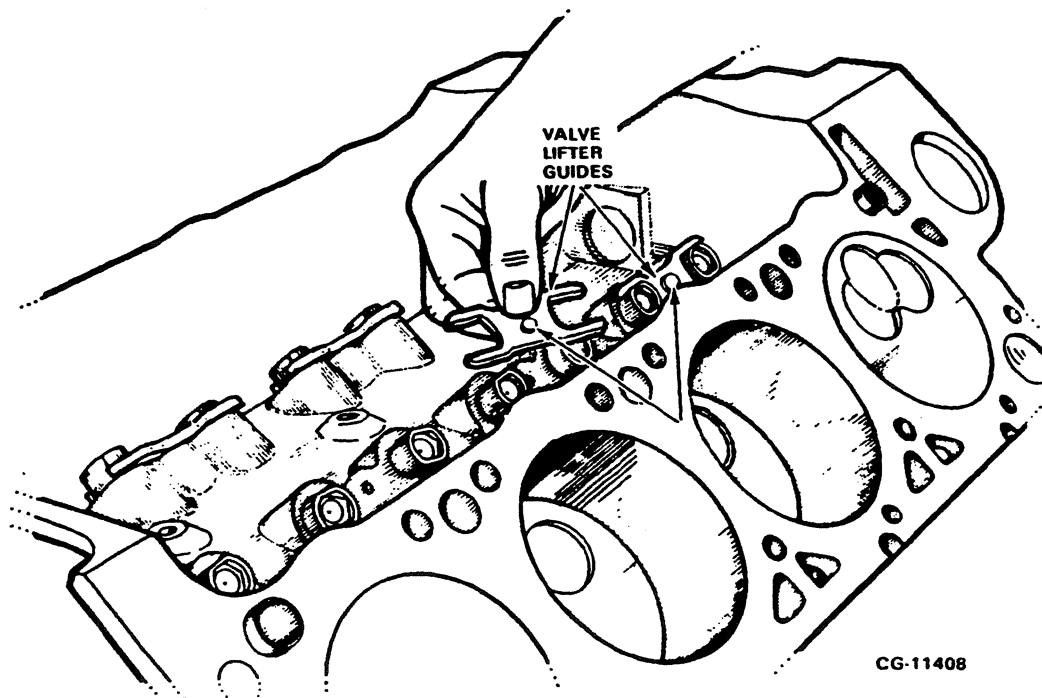


Figure 4.24. Hydraulic Valve Lifter Guide Installation

# **SERVICE MANUAL**

## **CONNECTING RODS, PISTONS AND RINGS**

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### **SECTION 5 INDEX**

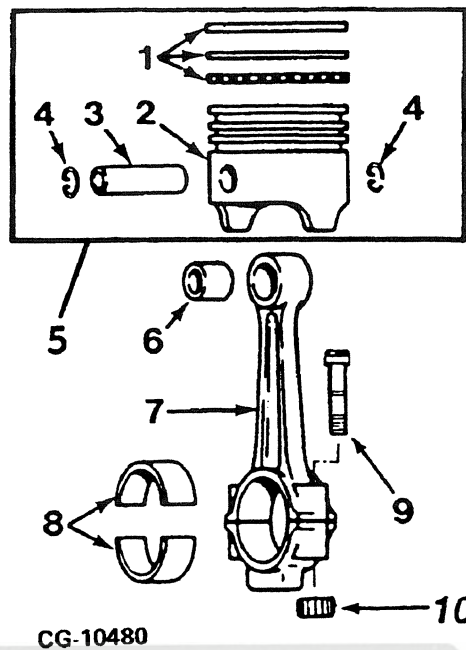
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# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

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Figure 5.1. Connecting Rods, Pistons and Rings

- |                    |                            |
|--------------------|----------------------------|
| 1. Piston Ring Set | 6. Pin Bushing             |
| 2. Piston          | 7. Connecting Rod          |
| 3. Piston Pin      | 8. Connecting Rod Bearings |
| 4. Retainer Rings  | 9. Connecting Rod Bolts    |
| 5. Piston Assembly | 10. Connecting Rod Nuts    |

## SPECIFICATIONS

### CONNECTING RODS:

Material	I-Beam Section – Steel Forging
Rod Length Center to Center	7.128"–7.132" (181.05–181.15 mm)
Bushing Bore Diameter (Pin End)	1.235"–1.236" (31.37–31.39 mm)
Bushing Bore Finish	63–125 RMS
Piston Pin Bushing I.D	1.1105"–1.1108" (28.20–28.21 mm)
Bearing Bore Diameter (Crankshaft End)	2.6905"–2.6915" (68.34–68.36 mm)
Maximum Out of Round	0.0005" (0.0127 mm)
Maximum Taper/Inch	0.0005" (0.0127 mm)
Connecting Rod Bearing I.D	2.5001"–2.5016" (63.50–63.54 mm)
Connecting Rod Bearing Running Clearance	0.0011"–0.0036" (0.0280–0.091 mm)
Connecting Rod Side Clearance	0.012"–0.024" (0.30–0.060 mm)
Connecting Rod Alignment ( Max. Total Difference)	
Twist	0.002"/in.(0.0508 mm/in.)
Bend	0.001"/in. (0.0254 mm/in.)
Weight – Complete rod without Bearing	1140–1156g.
Weight – at pin end (Non-Service Spec.)	328–336g.
Weight – at journal end (Non-Service Spec.)	812–820g.
Surface Finish – Bearing Bore (Crankshaft End)	50–90 RMS
Surface Finish – Installed Bushing (Pin End)	16 RMS

## SERVICE MANUAL

### CONNECTING RODS, PISTONS AND RINGS

#### SPECIFICATIONS (Continued)

##### PISTONS:

Material ..... Aluminum Alloy  
Skirt Diameter (Measured 1.23" below oil groove at 90° to the piston pin). Measure only at room temperature 68° F. (20° C)

● Production Piston (See Note)

Class U .....	4.10325" ± 0.00025"	(104.223 mm ± 0.006 mm)
Class B .....	4.10375" ± 0.00025"	(104.235 mm ± 0.006 mm)
Class A .....	4.10425" ± 0.00025"	(104.248 mm ± 0.006 mm)
Class C .....	4.10475" ± 0.00025"	(104.261 mm ± 0.006 mm)
Class D .....	4.10525" ± 0.00025"	(104.273 mm ± 0.006 mm)

● Service Piston

Standard Size .....	4.10425" ± 0.00025"	(104.247 mm ± 0.006 mm)
.010" Oversize .....	4.11425" ± 0.0005"	(104.502 mm ± 0.013 mm)
.020" Oversize .....	4.12425" ± 0.0005"	(104.756 mm ± 0.013 mm)
.030" Oversize .....	4.13425" ± 0.0005"	(105.010 mm ± 0.013 mm)

**NOTE:** For corresponding bore diameters and class fit, refer to Section 6, SPECIFICATIONS

##### Clearance in Cylinder Bore

Cylinder No. 1 thru 6 .....	0.0055"–0.0085"	(0.0380–0.216 mm)
Cylinder No. 7 and 8 .....	0.0060"–0.0085"	(0.152–0.216 mm)

##### PISTONS PINS:

Length .....	2.692"–2.702"	(68.38–68.63 mm)
Diameter .....	1.1099"–1.1101"	(28.19–28.20 mm)

Pin Fit @ Room Temperature 20°C (68°F)

● Clearance in Rod .....	0.0004"–0.0009"	(0.010–0.022 mm)
● Clearance in Piston .....	0.0003"–0.0007"	(0.007–0.018 mm)

##### PISTON RINGS:

###### Ring Diameter (Standard)

Top .....	4.11"	(104.39 mm)
2nd .....	4.11"	(104.39 mm)
Oil Control .....	4.11"	(104.39 mm)

###### Fit in Groove (Side Clearance) [Engine S/N 598753 and Below]

Top .....	0.002"–0.004"	(0.05–0.10 mm)
2nd .....	0.002"–0.004"	(0.05–0.10 mm)
Oil Control .....	0.001"–0.003"	(0.02–0.07 mm)

###### Fit in Groove (Side Clearance) [Engine S/N 598754 and Above]

Top .....	0.002"–0.004"	(0.05–0.10 mm)
2nd .....	0.003"–0.005"	(0.07–0.12 mm)
Oil Control .....	0.001"–0.003"	(0.02–0.07 mm)

###### Ring Gap in Bore [Engine S/N 598753 and Below]

Top .....	0.013"–0.045"	(0.33–1.14 mm)
2nd .....	0.060"–0.085"	(1.52–2.16 mm)
Oil Control .....	0.008"–0.030"	(0.20–0.76 mm)

###### Ring Gap in Bore [Engine S/N 598754 and Above]

Top .....	0.013"–0.023"	(0.33–0.58 mm)
2nd .....	0.062"–0.072"	(1.57–1.83 mm)
Oil Control .....	0.010"–0.020"	(0.25–0.51 mm)

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

Section 5  
Page 3

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### SPECIFICATIONS (Continued)

#### SPECIAL TORQUES

Connecting Rod Nuts ..... Step 1 - 38 lbf-ft. (51 N•m)  
Step 2 - 51 lbf-ft. (69 N•m)

#### SPECIAL SERVICE TOOLS

<u>Tool No.</u>	<u>Description</u>
ZTSE-4153	Connecting Rod Guide Protector Caps
ZTSE-4154	Connecting Rod Bushing Remover and Installer
SE-2218	Honing Machine

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

### COMPONENT IDENTIFICATION

**NOTE:** Effective with Engine Serial No. 598754 and above, the following product improvements were introduced:

- A new .1175 in. wide top compression ring with a molybdenum coating replaces the .0775 in. wide chrome plated top ring.
- A new .1335 in. wide chrome plated gray iron oil control ring replaces the .1085 in. wide chrome plated nodular iron oil ring.
- The piston was revised to accommodate the ring changes by increasing the corresponding ring groove widths. Refer to Figures 5.3A and 5.3B.

#### ● Pistons

1. The piston is best identified by the production part number which appears on top of the piston as shown in Figure 5.2.

**IMPORTANT**

WHEN ORDERING PISTON RING PACKAGES OR PISTON & RING PACKAGES CHECK THE ENGINE SERIAL NUMBER TO ASSURE THAT CORRECT PARTS ARE OBTAINED. REFER TO 7.3 L DIESEL ENGINE PARTS CATALOG FOR CORRECT PACKAGE PART NUMBERS.

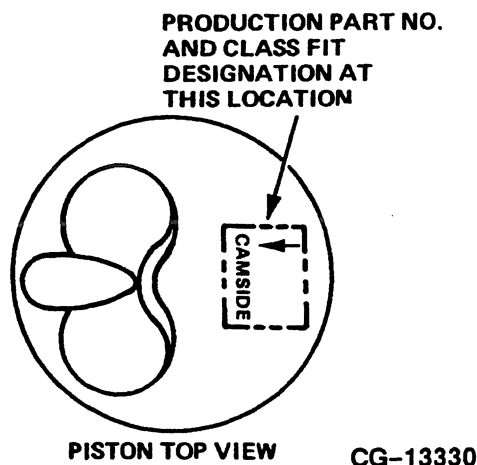


Figure 5.2. Piston Identification

REVISED PISTON RING GROOVE WIDTHS

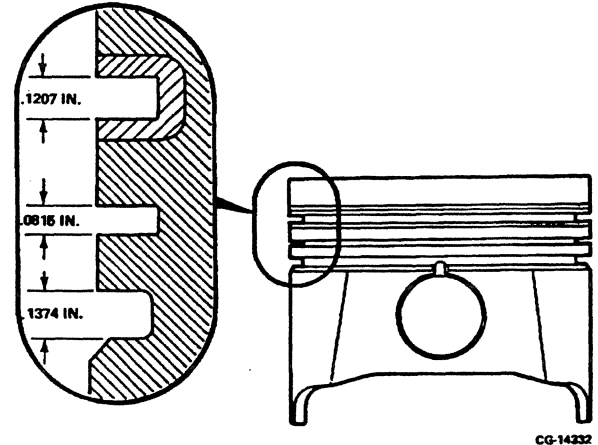


Figure 5.3A. Revised Piston Ring Groove Widths

PRIOR PISTON RING GROOVE WIDTHS

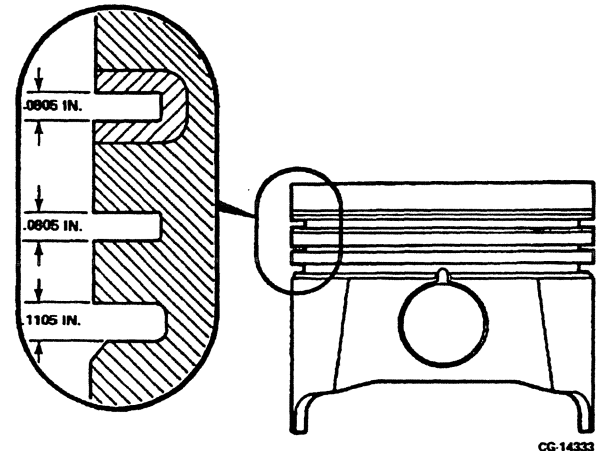


Figure 5.3B. Prior Piston Ring Groove Widths

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

Section 5  
Page 5

### COMPONENT IDENTIFICATION

#### ● Pistons – Continued

2. All 7.3 Liter Diesel Engines have a "CUT-BACK LAND" piston design. Refer to **Figure 5.4**.

Cutback refers to the pistons smaller diameter above the top ring groove compared to the diameter below the top ring.

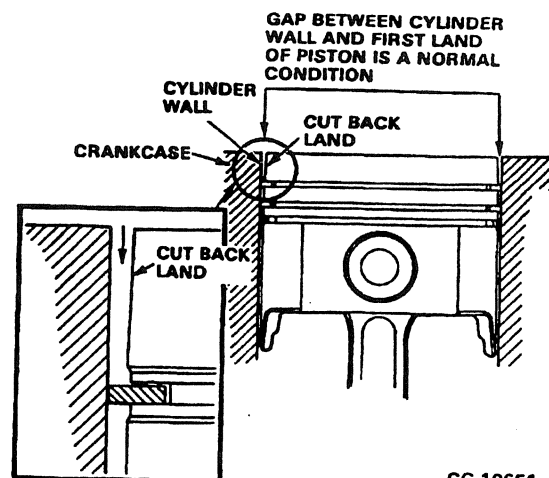


Figure 5.4. Piston with Cutback Land

#### ● Rings

1. The top compression ring is identified by one indentation mark located on top of the ring, and ring width as shown in **Figure 5.5**.

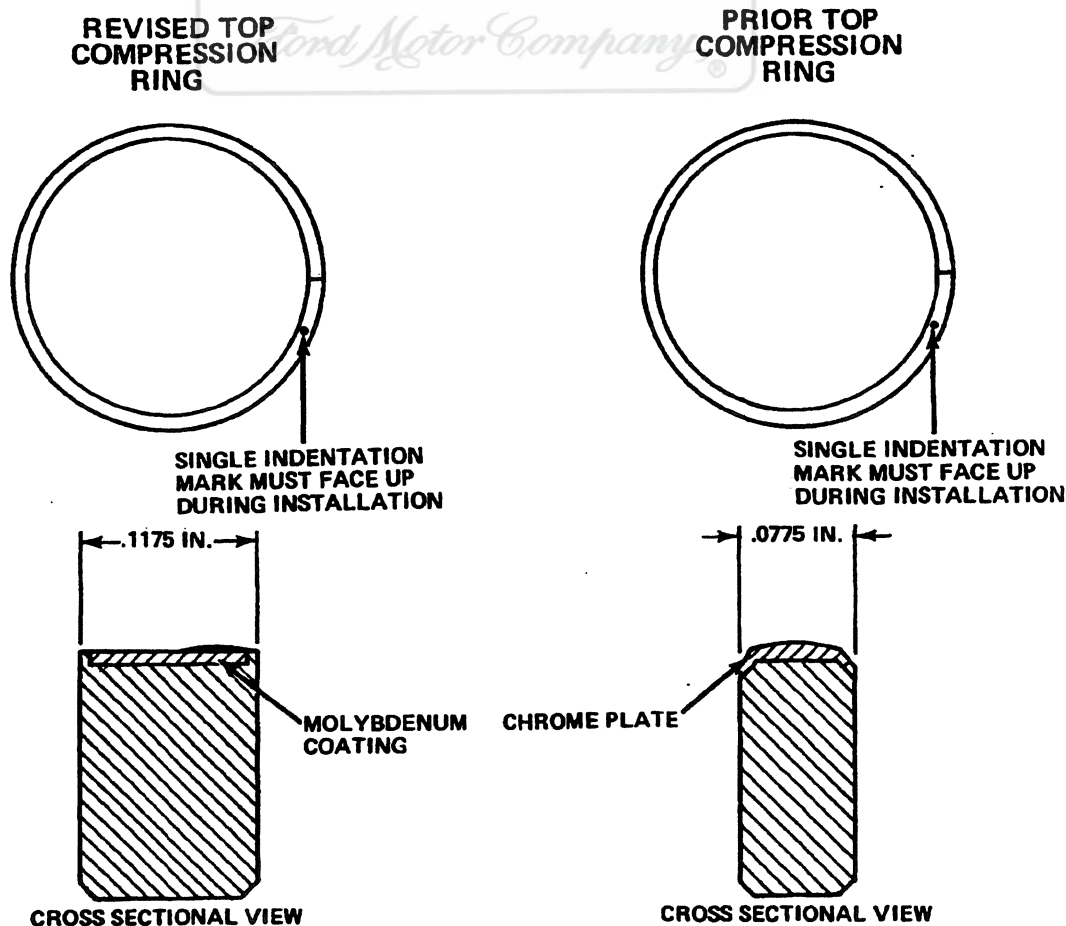


Figure 5.5. Top Compression Ring



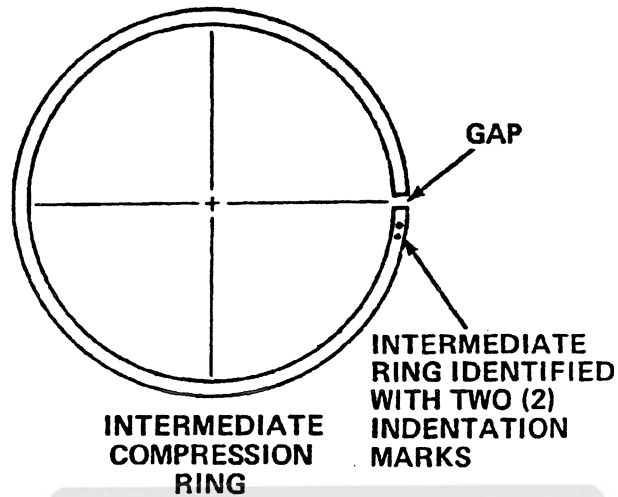
# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

### COMPONENT IDENTIFICATION

#### ● Pistons – Continued

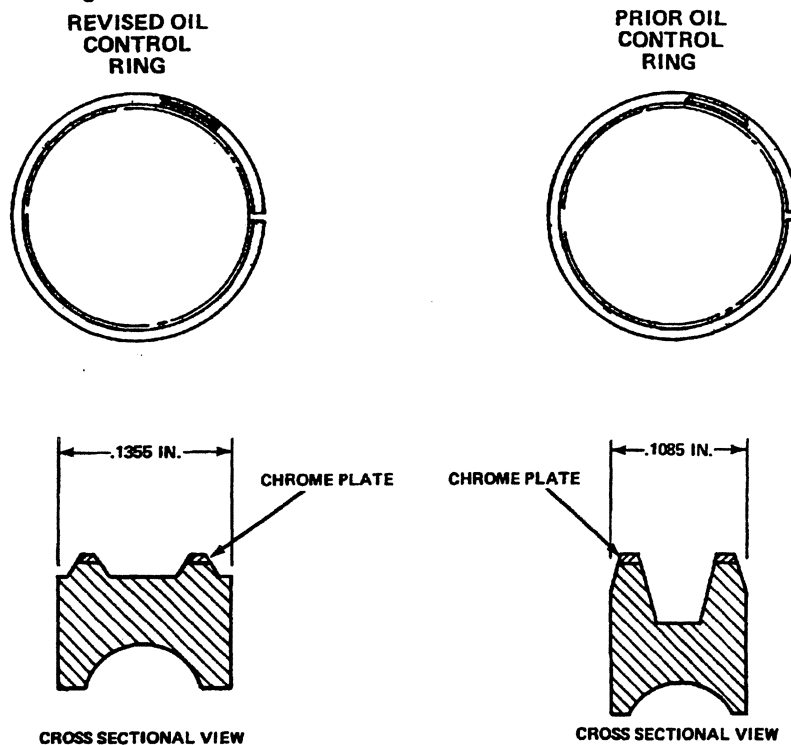
2. The intermediate compression ring is identified by two indentation marks located on top of the ring, **Figure 5.6**.



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Figure 5.6. Ring Identification

3. The wide vs. narrow oil control ring is identified as shown in **Figure 5.7**



CG-14331

Figure 5.7. Oil Control Ring [Wide vs. Narrow]

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

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### CONNECTING RODS, PISTONS AND RINGS

#### (Removal & Reassembly)

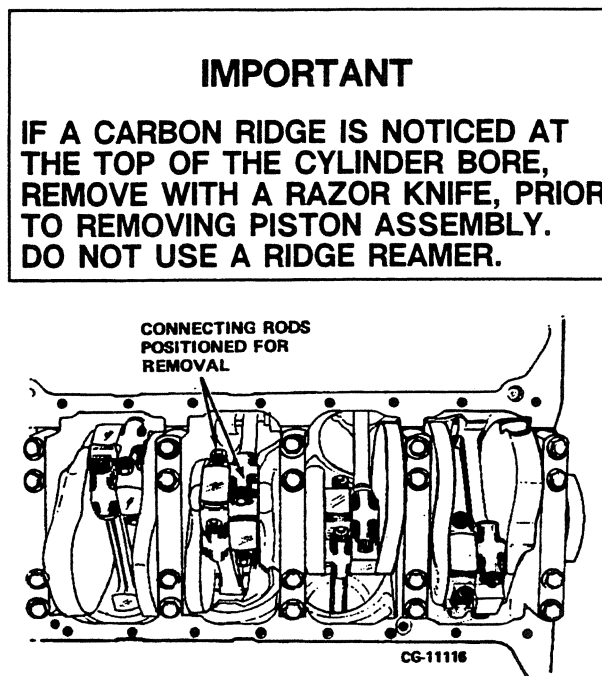
##### ■ Removal

Remove the following:

Glow Plug Harness and Controller  
Injection Lines (Low Pressure)  
Injection Pump (w/High Pressure Lines)  
Intake Manifold  
Valley Pan and Gaskets  
Exhaust Manifolds  
Oil Dipstick  
Injection Nozzles  
Cylinder Heads  
Oil Pan

Refer to the appropriate manual section for detailed disassembly procedures.

1. Rotate the crankshaft to position the journals for removal of the connecting rod assemblies, **Figure 5.8**.



**Figure 5.8. Positioning Connecting Rods for Removal**

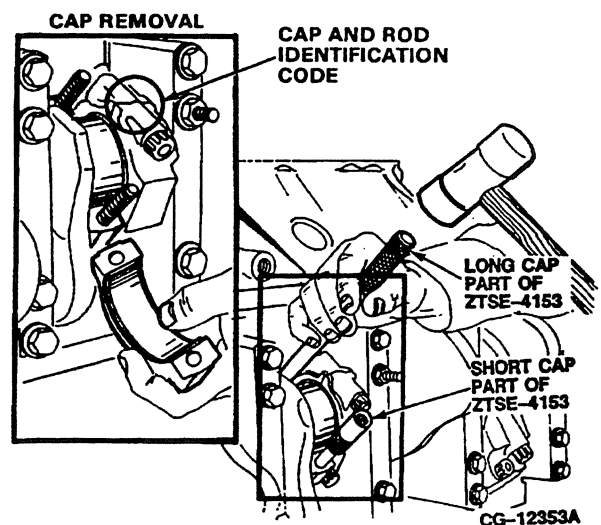
2. Remove the two connecting rod retaining nuts.

**NOTE:** Do not use a power wrench for removing connecting rod nuts. Such practice may cause seizure of the connecting rod nut or bolt threads.

#### IMPORTANT

**INSTALL THE ALUMINUM CONNECTING ROD GUIDE PROTECTOR CAPS ZTSE-4153 OVER THE CONNECTING ROD BOLTS. THIS PREVENTS DAMAGE TO THE CRANKSHAFT JOURNALS, FIGURE 5.9.**

3. Remove the cap and push the connecting rod and piston assemblies from the cylinder bore, **Figures 5.9 and 5.10**. Replace the cap and the bearing inserts on the rod so the identification codes match. Identify the connecting rods and piston assemblies upon removal so they can be reinstalled in their respective cylinders.



**Figure 5.9. Connecting Rod Cap Removal**

**NOTE:** Use care when removing piston assembly to prevent component damage.

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

### CONNECTING RODS, PISTONS AND RINGS – Continued

#### (Removal & Reassembly) – Continued

##### ■ Removal – Continued

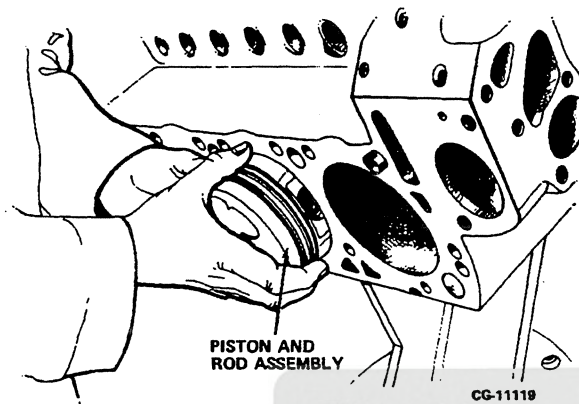


Figure 5.10. Connecting Rod and Piston Removal

4. Remove the piston rings (1, Figure 5.1) using a piston ring expander. Remove the top compression ring first then the remaining rings in order.

##### ■ Cleaning

1. Immerse the connecting rod with piston and the piston rings in a soap and water solution. Let soak until carbon deposits are soft.
2. Clean rod, pistons and rings using a non-metallic brush.
3. Assure all ring grooves are clean.

**NOTE: NEVER USE A CAUSTIC SOLUTION OR A WIRE BRUSH FOR CLEANING ALUMINUM PISTONS.**

4. Clean all rod bolt threads and bolt holes thoroughly.

##### ■ Inspection

1. Visually inspect the connecting rod, bolts and nuts for nicks or damage.

**NOTE:** When lubricated with clean engine oil, the nuts must screw onto the bolts by hand. If the nut will not screw in by hand, discard and use new nuts and bolts.

2. Visually inspect the pistons for scuffed or scored skirts and cracked or worn lands. Replace the piston as required.

3. Refer to Piston and Ring Inspection in this section.

##### ■ Installation

### IMPORTANT

**DURING INSTALLATION, INSTALL THE ALUMINUM CONNECTING ROD GUIDE PROTECTOR CAPS (ZTSE-4153) OVER THE CONNECTING ROD BOLTS. THIS PREVENTS DAMAGE TO THE CRANKSHAFT JOURNALS. (SEE NOTE AND FIGURE 5.11).**

**NOTE:** The rod bearing inserts must be in place before installing protector caps ZTSE-4153.

1. Turn the crankshaft so the No.1 crankpin is at the bottom of its stroke.
2. Coat the cylinder bores, crankshaft journals, pistons and piston rings with clean engine oil. Install rings using piston ring expander.

**NOTE:** Top and intermediate (2nd) rings are to be installed with identification marks facing up. Refer to Figures 5.4 and 5.5.

3. Insert the piston and rod into the piston ring compressor (with ring gaps spaced 120° apart). Carefully push down on the piston until it is in the cylinder. Avoid striking the cylinder wall and crankshaft. Figure 5.12. Repeat for each rod and piston assembly.

**NOTE:** Be careful when installing the piston and rod assembly so the crankpin and/or cylinder bore are not damaged.

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

Section 5  
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### CONNECTING RODS, PISTONS AND RINGS – Continued

#### (Removal & Reassembly) – Continued

##### ■ Installation – Continued

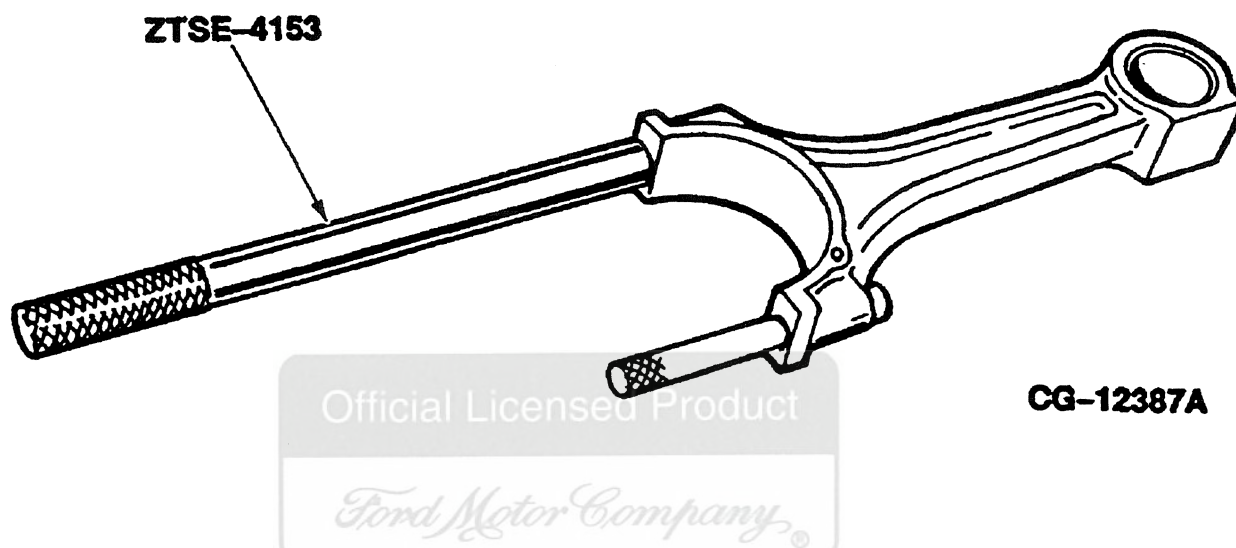


Figure 5.11. Connecting Rod Installation Guide and Protector Caps Installed on Connecting Rod Bolts

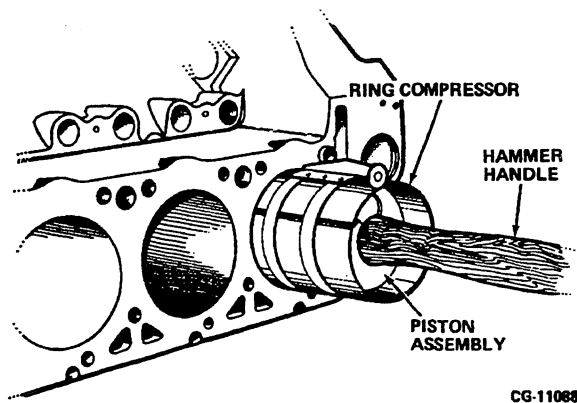


Figure 5.12. Installation of Piston in Cylinder Block

### IMPORTANT

THE CONNECTING ROD AND PISTON MUST BE POSITIONED AS FOLLOWS:

- CONNECTING ROD – THE LARGE CHAMFER (9, FIGURE 5.13) MUST BE LOCATED NEXT TO THE CRANKSHAFT FILLET (4, FIGURE 5.13)
- PISTON – THE ARROW ON TOP OF THE PISTON (FIGURE 5.14) MUST FACE CAM SIDE OF THE ENGINE BLOCK.

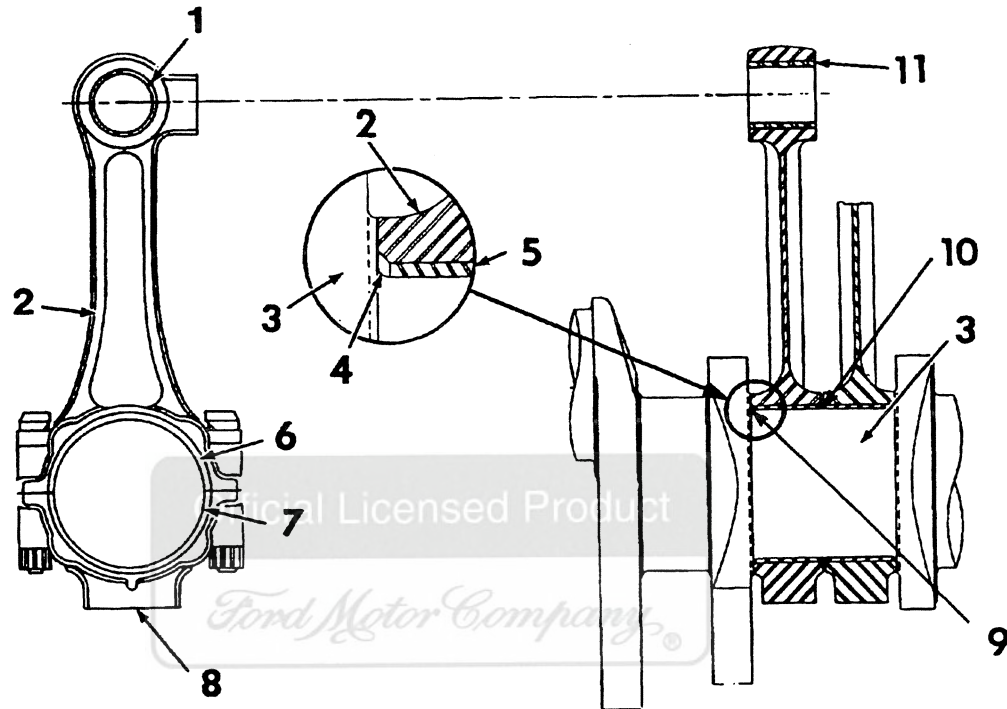
# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

### CONNECTING RODS, PISTONS AND RINGS – Continued

#### (Removal & Reassembly) – Continued

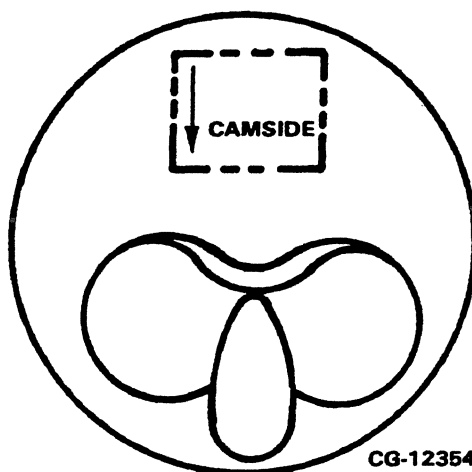
##### ■ Installation – Continued



CG-10560

Figure 5.13. Illustrating Proper Installation of Connecting Rod to Crankshaft

- |                      |                                   |  |
|----------------------|-----------------------------------|--|
| 1. Split in Bushing  | 5. Bearing                        | 9. Large Chamfer Side (Next to Fillet) |
| 2. Connecting Rod    | 6. Connecting Rod Bearing – Upper | 10. Small Chamfer Side                 |
| 3. Crankshaft        | 7. Connecting Rod Bearing – Lower | 11. Piston Bushing Pin                 |
| 4. Crankshaft Fillet | 8. Connecting Rod Bearing Cap     |  |



CG-12354

Figure 5.14. 7.3L Piston (Top View)

4. Remove connecting rod guide protector caps.

5. Coat bearing shell wear surface with clean engine oil and install connecting rod bearings and caps.

**NOTE:** Rods and caps are matched. Assemble connecting rod and cap with matching identification code on the same crankpin from which removed. Refer to Figure 5.15.

**NOTE:** Follow instructions for "Fitting Connecting Rod Bearings", in this section, prior to FINAL torque of connecting rod bearing caps.

6. Apply clean engine oil to clean bolt threads prior to tightening.



# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

Section 5  
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### CONNECTING RODS, PISTONS AND RINGS – Continued

#### (Removal & Reassembly) – Continued

##### ■ Installation – Continued

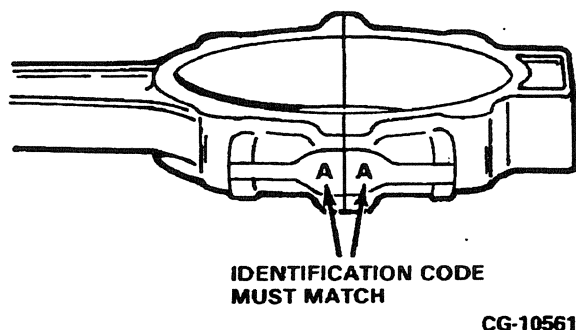


Figure 5.15. Connecting Rod Identification Code (Must be matched prior to assembly)

**NOTE:** Do not use an air wrench when installing connecting rod bolts and nuts. Such practice will cause seizure of the connecting rod bolt or nut threads.

7. Tighten connecting rod bolts and nuts to specified torque.

8. Repeat steps 1–7 for the remaining connecting rods and pistons.

9. Recheck connecting rod end clearance using a feeler gauge as outlined under "Fitting Connecting Rod Bearings".

10. Reinstall the following:

- Oil Pan
- Cylinder Heads w/New Gaskets
- Injection Nozzles w/New Copper Gasket
- Oil Dipstick
- Exhaust Manifolds
- Valley Pan and Gaskets
- Intake Manifold
- Injection Pump
- Injection Lines
- Glow Plug Harness and Controller

Refer to appropriate manual section for detailed assembly instructions.

11. Fill engine with specified type and quantity of oil prior to operation.

### CONNECTING RODS, PISTONS AND RINGS (Reconditioning)

##### ■ Piston Disassembly

1. Remove piston rings using piston ring expander tool.

2. Disconnect the connecting rod from the piston pin assembly as follows:

- a. Using a suitable pliers (Figure 5.16), remove the piston pin retaining rings from each end of the pin.

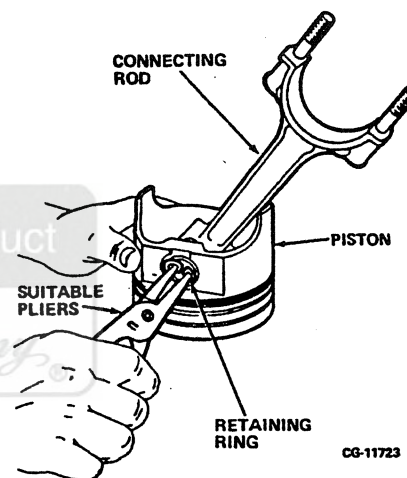


Figure 5.16. Removing Piston Pin Retainers

3. Insert piston in any suitable vise (piston O.D. must be protected from damage) and drive piston pin (Figure 5.17) from piston and rod assembly using a nylon rod or brass drift and a soft hammer.

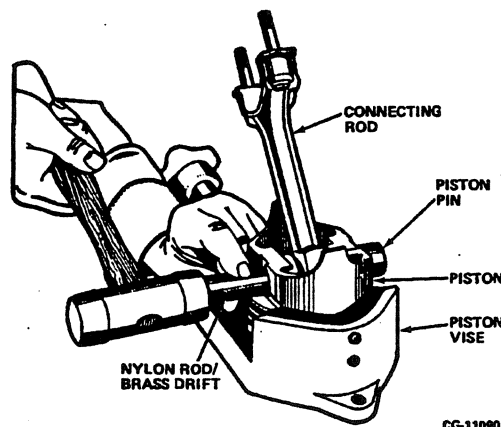


Figure 5.17. Removing Piston Pin

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

### CONNECTING RODS, PISTONS AND RINGS (Reconditioning)

#### ■ Piston Disassembly – Continued

4. Separate connecting rod from piston.

### IMPORTANT

**MAKE SURE PARTS ARE MARKED SO THEY ARE REINSTALLED IN THEIR RESPECTIVE CYLINDERS, UNLESS DEFECTIVE.**

#### ■ Cleaning

1. Clean the aluminum piston using a soap and water solution; soak then clean, using a non-metallic brush. All disassembled components, may be cleaned using a suitable solvent:

- Piston Rings
- Piston Pins
- Piston Pin Retainers
- Connecting Rod Caps
- Connecting Rods
- Connecting Rod Bolts & Nuts
- Connecting Rod Bearing Inserts

**NOTE: Never use a caustic solution or a wire brush for cleaning aluminum pistons.**

2. Assure all piston ring grooves are cleaned thoroughly.

#### ■ Inspection

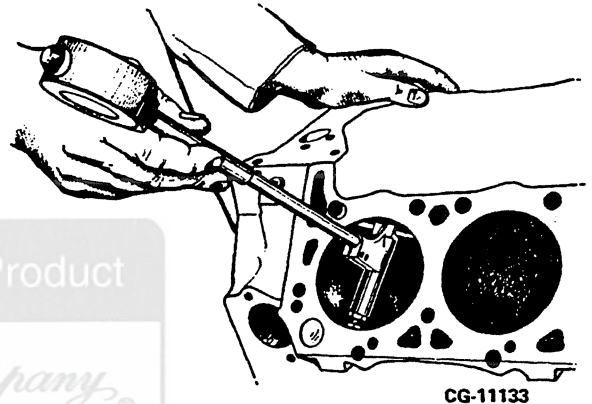
### ● PISTONS

1. Visually inspect the pistons for scuffed or scored skirts, cracked or worn ring lands and cracked or scuffed pin bores, discarding any showing such condition.
2. Piston pins should be inspected and measured for wear. If piston pins show signs of corrosion or etching or are not within specifications, they should be replaced with new pins. See "SPECIFICATIONS". Piston assemblies furnished for service replacement are complete with piston pins accurately fitted.

### ● PISTON SELECTION GUIDELINES

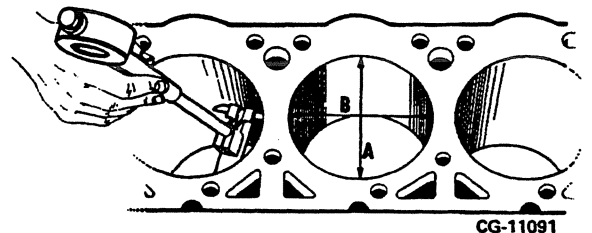
1. If pistons require replacement, a standard or oversize piston must be chosen as follows:

- a. Measure cylinder bore diameters using a telescoping gauge with outside micrometer or dial bore gauge to determine cylinder out-of-round and taper, Figure 5.18.



**Figure 5.18. Checking Cylinder Bore Using Dial Bore Gauge (At Top of Ring Travel)**

- b. Measure the diameter of each cylinder bore at the top of the piston ring travel at a right angle to the crankshaft ("A", Figure 5.19) and to the centerline of the crankshaft ("B", Figure 5.19). Record the readings and calculate the difference.



**Figure 5.19. Checking Cylinder for Out-of-Round and Taper (Dial Indicator Shown At Bottom of Ring Travel)**

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

Section 5  
Page 13

### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) – Continued

#### ■ Inspection – Continued

- c. Repeat measurements at the "Top" and at the "Bottom" of ring travel. Record the readings and calculate the difference.
- d. The out-of-round condition at the top and bottom of ring travel is the difference between the "Top" reading and "Bottom" reading for each set of measurements.
- e. Cylinder bore taper is the difference between the cylinder bore diameters measured at the "Top" of ring travel (Figure 5.20) and the "Bottom" of ring travel (Figure 5.20) (AT RIGHT ANGLES TO THE CENTERLINE OF THE CRANKSHAFT).

**NOTE:** Refer to "Specifications" for maximum out-of-round and cylinder bore taper.

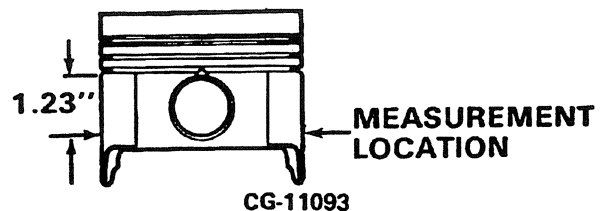


Figure 5.21. Piston Skirt Dia. Measurement (90° to pin bore)

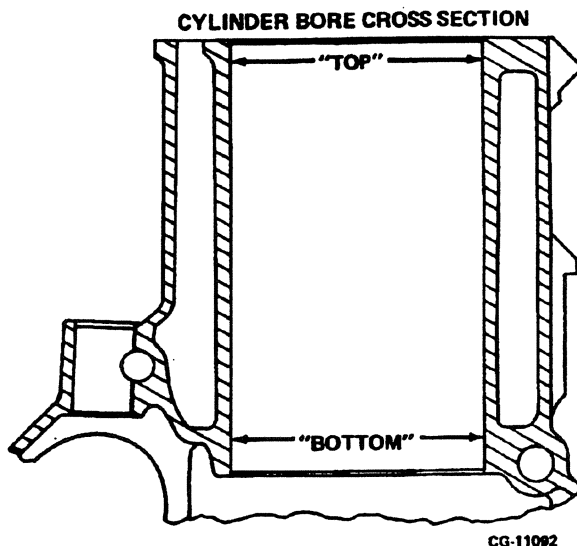


Figure 5.20. Checking Cylinder Bore Taper

- f. If taper and out-of-round for cylinder walls are within specifications use new standard size service pistons.

- g. If cylinder bores exceed out-of-round and/or taper specifications reboring may be required as described in Section 6. Such cylinder bore reconditioning will require the use of oversize service pistons. In addition to the standard size service piston .010", .020" and .030" oversize pistons are available. Verify piston size by measuring skirt diameter (Figure 5.21).

#### IMPORTANT

THE SIZE PISTON SELECTED SHOULD BE LARGE ENOUGH TO PERMIT CLEANING UP THE CYLINDER BORE AND PROVIDE THE PROPER RUNNING CLEARANCE IN THE CYLINDER BORE (SEE SPECIFICATIONS).

- 2. For detailed procedures on reboring the cylinder bore refer to Section 6 "CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE".

## SERVICE MANUAL

### CONNECTING RODS, PISTONS AND RINGS

#### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) – Continued

##### ■ Inspection – Continued

##### ● PISTON RINGS

**NOTE:** Faulty rings cannot always be detected by visual inspection. Therefore, whenever a piston is removed from a cylinder, it is recommended that the piston rings be replaced.

1. Visually inspect **NEW** rings for cleanliness.
2. Prior to installing the rings on the piston, check each ring for proper gap as follows:

- a. Push the ring down into the cylinder bore making sure the ring is square with the cylinder wall.
- b. Measure the gap between the ends of each ring with a feeler gauge as shown in Figure 5.22.

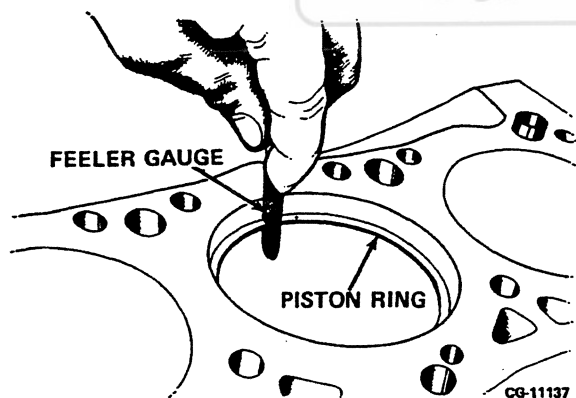


Figure 5.22. Checking Ring Gap

- c. If the gap does not meet the **SPECIFICATIONS**, select another ring.

**NOTE:** Piston rings are available for service in standard sizes as well as .010", .020" and .030" oversize piston rings. Each ring should be fitted and checked in the cylinder in which it is to be used. Mark accordingly so they are installed in their respective bores.

3. Check side clearance of piston rings in the groove of the piston on which they are to be installed, as follows:

- a. Place the outer edge of the ring in the piston groove (Figure 5.23).
- b. Roll the ring, in its respective groove, entirely around the piston. Make sure the ring is "free" in the groove.
- c. With a feeler gauge (Figure 5.23) check the side clearance of each ring in its respective groove. (See **SPECIFICATIONS**).

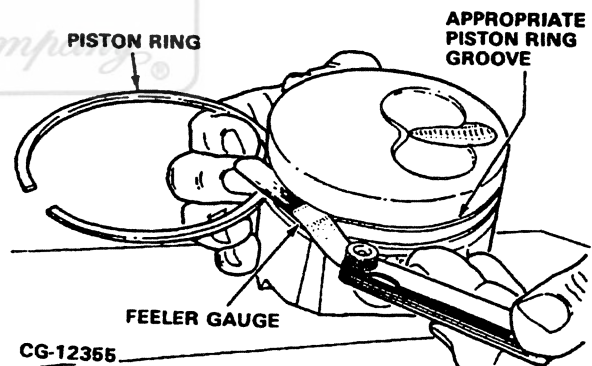


Figure 5.23. Checking Ring-to-Groove Side Clearance with Feeler Gauge

##### ● CONNECTING RODS

1. Measure inside diameter of piston pin bushing in connecting rod using a telescoping gauge and a micrometer, Figure 5.24. (See **SPECIFICATIONS**). If bushings are worn, new bushing must be installed after connecting rod passes inspection.



# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

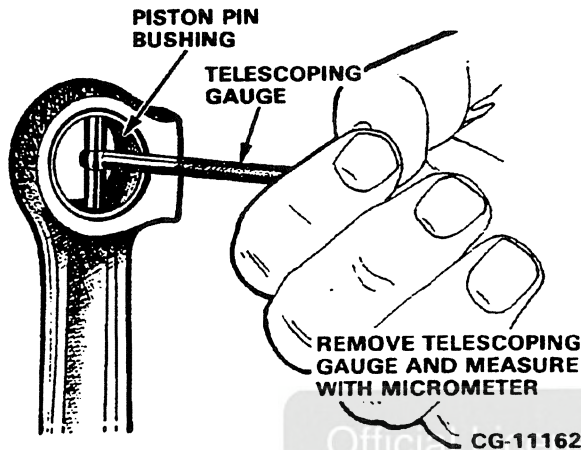
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### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) – Continued

#### ■ Inspection – Continued

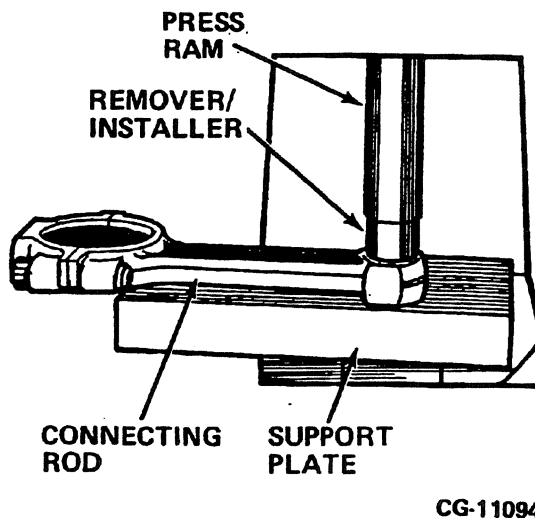
#### ● CONNECTING RODS – Continued

3. Clean the connecting rod thoroughly and visually inspect for defects. Using telescoping gauge and a micrometer, check connecting rod piston pin bushing bore diameter, **Figure 5.26**. (See **SPECIFICATIONS**.) Replace as required.

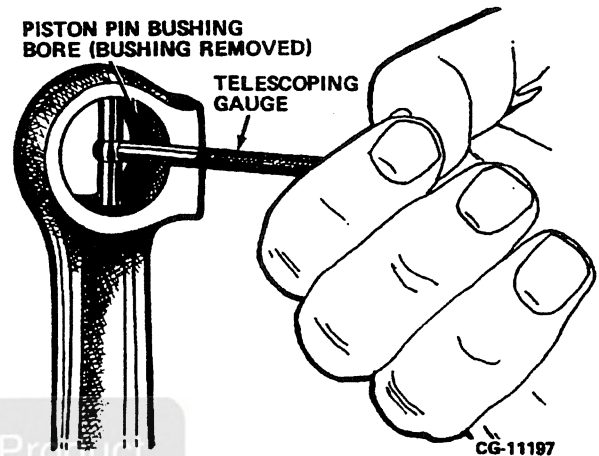


**Figure 5.24. Checking Connecting Rod Piston Pin Bushing I.D.**

2. Remove any worn bushing using Connecting Rod Bushing Remover and Installer Tool ZTSE-4154. Place connecting rod under a hydraulic press in line with the properly sized hole on the support block and use ZTSE-4154 to press out the bushing, **Figure 5.25**.



**Figure 5.25. Using ZTSE-4154 Tool to Remove Worn Connecting Rod Bushing**

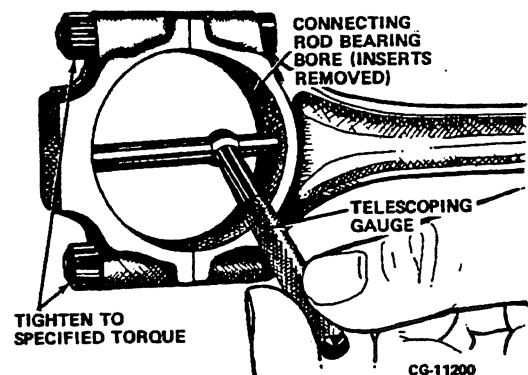


**Figure 5.26. Checking Connecting Rod Piston Pin Bushing Bore Diameter**

4. Continue connecting rod inspection (crankshaft end) as follows:

- Measure connecting rod bearing bore diameter (with bearing inserts removed), **Figure 5.27**. (See **SPECIFICATIONS**) for bearing bore I.D.

**NOTE:** Measure bore diameter with connecting rod nut tightened to specified special torque. Replace as required.



**Figure 5.27. Measuring Connecting Rod Bearing Bore Diameter**



## SERVICE MANUAL

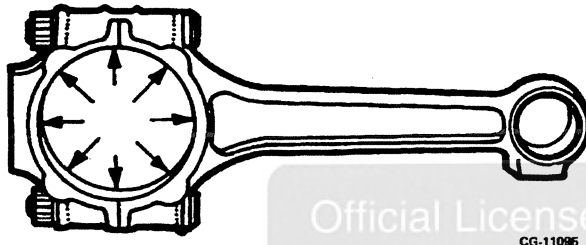
### CONNECTING RODS, PISTONS AND RINGS

#### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) – Continued

##### ■ Inspection – Continued

##### ● CONNECTING RODS – Continued

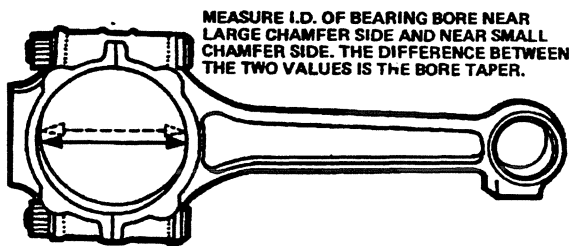
- b. With connecting rod assembled and rod bolts and nuts tightened to specified special torque use a dial bore gauge indicator to measure out-of-round, **Figure 5.28** (see **SPECIFICATIONS**). Replace rod if maximum out-of-round specification is exceeded.



CG-11096

**Figure 5.28. Measuring Connecting Rod Bearing Bore Roundness**

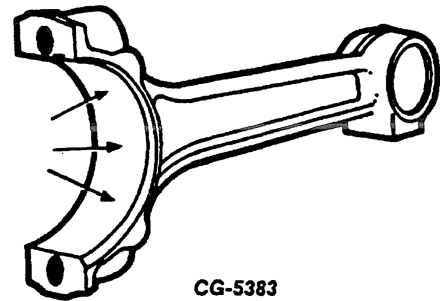
- c. Measure connecting rod bore taper (**Figure 5.29**), by measuring the bore I. D. near the large chamfer, record reading and measure the bore I.D. near the small chamfer, record reading. The difference between the two readings is the bore taper. (See **SPECIFICATIONS**). Replace rod if maximum bore taper is exceeded.



CG-10664

**Figure 5.29. Measuring Bearing Bore Taper**

- d. With connecting rod cap removed, visually inspect the surface finish of the connecting rod bearing bore. The bore must be smooth and free of scoring or nicks, **Figure 5.30**. Replace as required.



CG-5383

**Figure 5.30. Inspection of Connecting Rod Bearing Bore Surface Finish**

**NOTE:** Connecting rod inspection (4a–d) can be made using accurate bore gauging instruments. Refer to instructions included with the gauges.

##### ● CONNECTING ROD BEND AND TWIST

5. An engine component wear pattern can be identified and used to diagnose a problem. Common examples of connecting rod wear pattern diagnostic clues are presented as follows:

- A shiny surface on edge of piston pin bushing usually indicates that a connecting rod is bent or piston pin hole is not in proper relation to piston skirt and ring grooves.
- Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, an improperly machined journal, or a tapered connecting rod bore.
- Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb action of entire piston, rings, and connecting rod assembly and may be the cause of excessive oil consumption.

#### IMPORTANT

**IF THE CONNECTING RODS DO NOT MEET THE REQUIREMENTS SET FORTH IN PARAGRAPHS 1–6 "CONNECTING ROD INSPECTION", REPLACE THE ENTIRE CONNECTING ROD ASSEMBLY.**

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

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### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) – Continued

#### ■ Repair

#### ● CONNECTING RODS

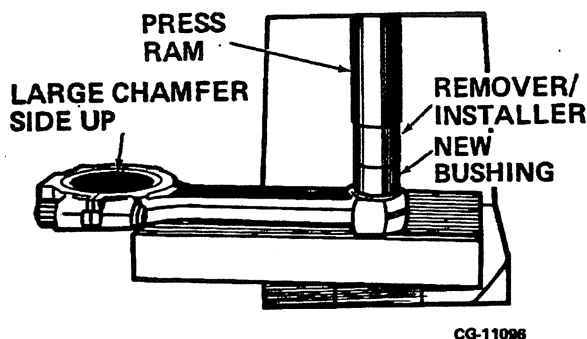
1. Install a new connecting rod bushing using installer tool ZTSE-4154 as follows:

a. Place the new bushing (4, **Figure 5.31**) on the remover/installer tool ZTSE-4154 (3, **Figure 5.31**) and lubricate the bushing O.D. with clean engine oil.

b. Place the connecting rod on a flat surface plate with the "large" chamfer side up (1, **Figure 5.31**)

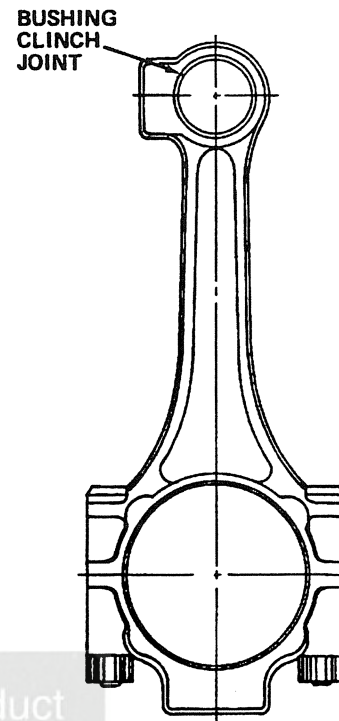
**NOTE:** The clinch joint (split) in the bushing must be located in the connecting rod as shown in **Figure 5.32**.

c. Press the new bushing in place flush or below the surfaces of both sides of the rod.

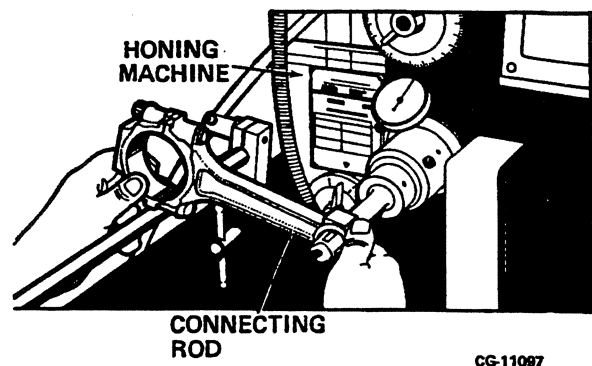


**Figure 5.31. Using ZTSE-4154 Tool to Install New Connecting Rod Bushing**

2. After bushing has been installed in the rod, it must be honed to the proper I.D. (see **SPECIFICATIONS**). Use SE-2218 honing machine, **Figure 5.33**.



**Figure 5.32. Location of Connecting Rod Bushing Clinch Joint (Split)**



**Figure 5.33. Honing Connecting Rod Bushing Using SE-2218**

#### ● BEARING FITTING PROCEDURE

1. If bearing-to-crankshaft running clearances exceed specifications, because of wear regrind the crankshaft and install undersize precision type bearing shells.

## SERVICE MANUAL

### CONNECTING RODS, PISTONS AND RINGS

#### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) – Continued

##### ■ Repair – Continued

##### ● CONNECTING RODS – Continued

### IMPORTANT

DO NOT ATTEMPT TO REDUCE JOURNAL-TO-BEARING RUNNING CLEARANCES BY REWORKING BEARING CAP, BEARINGS OR BOTH. GRIND THE CRANKSHAFT ONLY. REFER TO SECTION 6.

### CAUTION !



REWORKING THE BEARING CAP AND/OR BEARINGS WILL DESTROY THE ENGINEERED FIT OF THE BEARING SHELLS IN THEIR BORES (BEARING CRUSH).

2. Tighten the connecting rod bolts and nuts alternately and evenly to the specified torque, using an accurate torque wrench. (See **TORQUE SPECIFICATIONS**)

**NOTE: ABOUT BEARING CRUSH AND SPREAD!** Bearing shells must fit tightly in the bore. When bearing shells are inserted into the connecting rod and cap, they protrude above the parting line. This protrusion is required to achieve "BEARING CRUSH". Bearing shells are designed with "SPREAD". That is, the width across the open ends are slightly larger than the diameter of the connecting rod bore into which they are assembled, as shown in Figure 5.34A. This condition is designed into the bearing shell causing it to spread outward at the parting line when "CRUSH" load is applied by tightening the bolts. Some snap may be lost in normal use, but bearing replacement is not required because of a nominal loss of snap.

When the assembly is drawn up tight, the bearing is compressed, assuring a positive contact between the bearing back and the bore as shown in (2A & B, Figure 5.34B).

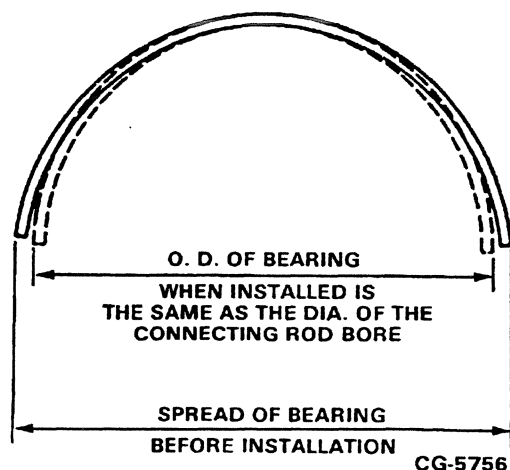


Figure 5.34A. Bearing Spread

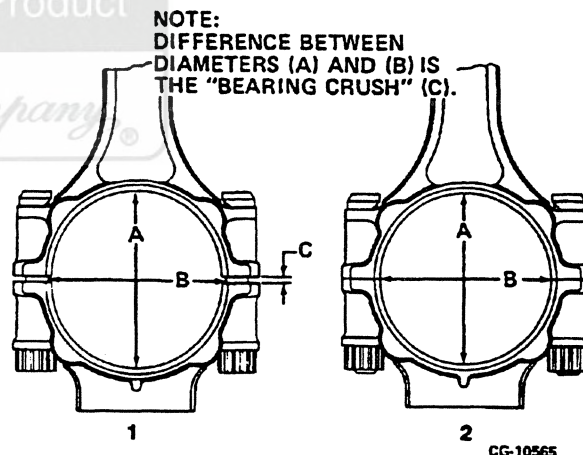


Figure 5.34B. Bearing Crush

3. Fit connecting rod bearings and measure bearing running clearance as follows:

- With bearing cap removed, wipe oil from the face of the bearing insert and exposed portion of the crankshaft journal.
- Place a piece of "Plastigage®" across the full width of the bearing about 1/4 in. off center.
- Install the cap and tighten bolts and nuts evenly and alternately to specified torque.

**NOTE:** Do not turn the crankshaft during running clearance check.

# SERVICE MANUAL

## CONNECTING RODS, PISTONS AND RINGS

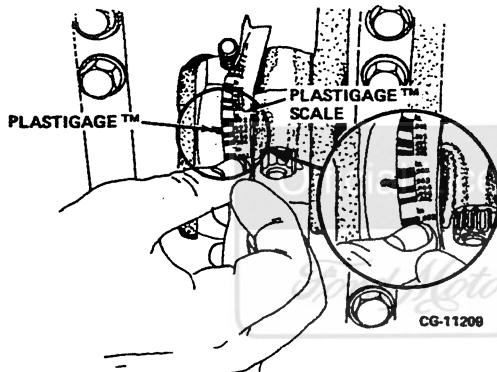
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### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) - Continued

#### ■ Repair - Continued

#### ● CONNECTING RODS - Continued

d. Remove bearing cap. The "Plastigage®" material will be found adhering to either the bearing shell or the crankshaft. **DO NOT REMOVE "PLASTIGAGE®"**. Use "Plastigage®" scale to measure widest point of flattened plastic material, **Figure 5.35**. The number within the graduated marks on the scale indicates the clearance in thousandths of an inch and millimeters (see **SPECIFICATIONS**).



**Figure 5.35. Checking Connecting Rod Bearing Clearance**

e. Remove the test material and repeat test for each connecting rod bearing.

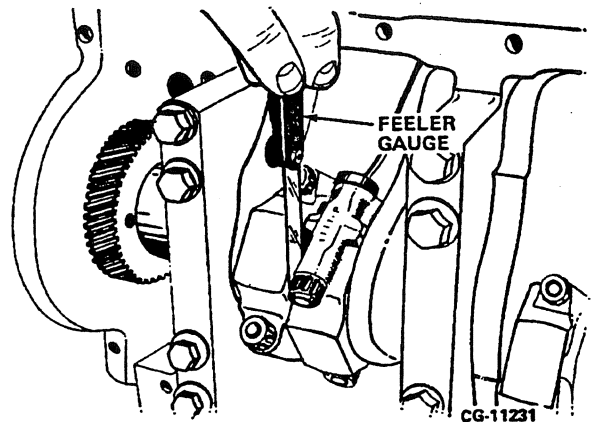
**NOTE:** With the precision bearings used, no problem should be encountered. However, if proper clearance is **NOT** achieved, a problem with the crankshaft may exist which requires regrinding and the use of undersize bearings. (Refer to Section 6 for Crankshaft Rework Information.)

Additionally, bearing cap torque is very important. Use a torque wrench which is known to be accurate. Repeat running clearance check procedure before condemning the crankshaft.

4. Check connecting rod side clearance, using a feeler gauge as shown in **Figure 5.36**. (See **SPECIFICATIONS**.)

**NOTE:** The connecting rod end clearance must be checked to be certain that the specified clearance exists.

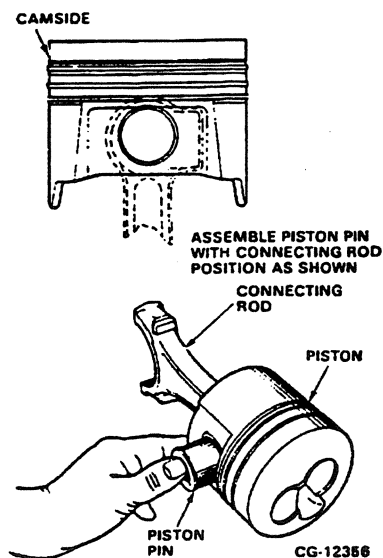
- Lack of clearance could indicate a damaged rod or a rod bearing out of position. Correct as required.
- Excessive clearance may require replacement of the rods or crankshaft. Correct as required.



**Figure 5.36. Checking Connecting Rod End Clearance**

#### ■ Reassembly

1. Lubricate piston pin with clean engine oil. Align rod bore and piston bore and insert piston pin. Push piston pin with thumb and install retainer snap rings, using suitable pliers. Make sure retainers seat fully with tension in the grooves. See **Figure 5.37**.



**Figure 5.37. Piston Pin Installation**



## SERVICE MANUAL

### CONNECTING RODS, PISTONS AND RINGS

#### CONNECTING RODS, PISTONS AND RINGS (Reconditioning) - Continued

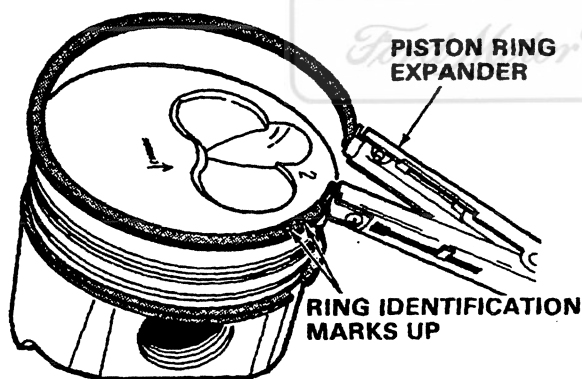
##### ■ Reassembly - Continued

##### ● CONNECTING RODS - Continued

2. Assemble the rings on the pistons to which they were fitted by using a piston ring expander tool, Figure 5.38.

**NOTE:** This type of tool is recommended to avoid over-expanding and also to expand the ring to a true circle to avoid distortion.

- Install rings with identification markings on ring facing up. Refer to Figures 5.5 and 5.6.
- Stagger the ring gaps 120° apart.



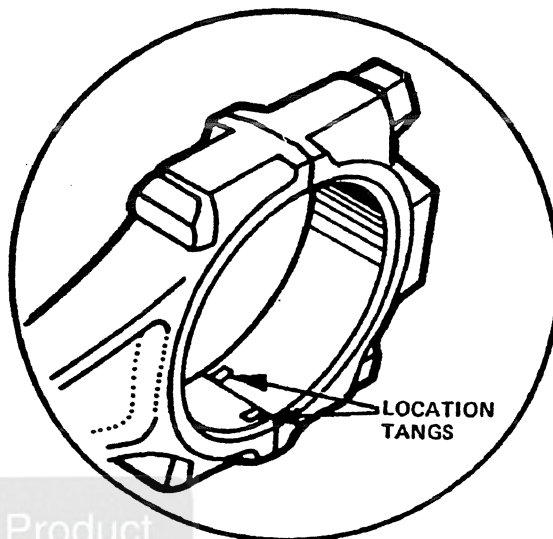
##### **IMPORTANT!**

INSTALL IN ORDER:  
OIL CONTROL RING,  
2ND COMPRESSION RING AND  
TOP COMPRESSION RING.  
SPACE RING GAPS 120° APART.

CG-12357

**Figure 5.38. Installing Piston Ring Using Piston Ring Expander Tool**

3. Install bearing shell inserts chosen during bearing fitting procedure. Bearing locator tangs (Figure 5.39) aid in correct insert installation.



CG-10567

**Figure 5.39. Bearing Shell Installation**

4. Follow installation procedure for connecting rod and piston assembly as described earlier in this section.

##### **IMPORTANT**

**BE SURE TO USE THE ALUMINUM CONNECTING ROD GUIDE PROTECTOR CAPS ZTSE-4153, TO PROTECT THE CRANKSHAFT JOURNALS.**

5. Recheck connecting rod end play (see SPECIFICATIONS).

6. Reinstall all other components removed. See unit section for detailed reassembly procedures.



# **SERVICE MANUAL**

## **CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE**

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## **CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE**

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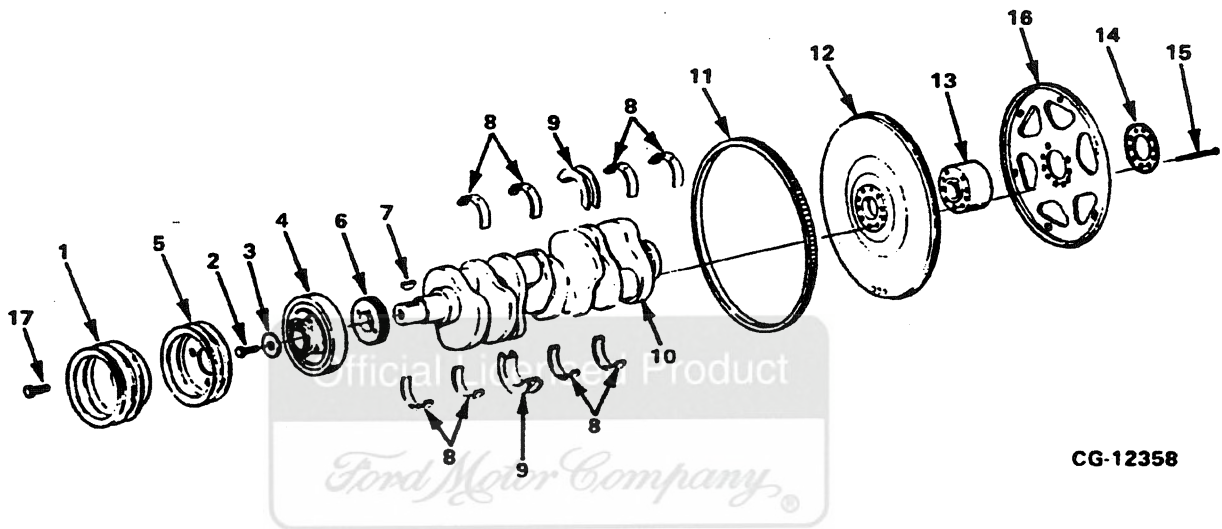
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# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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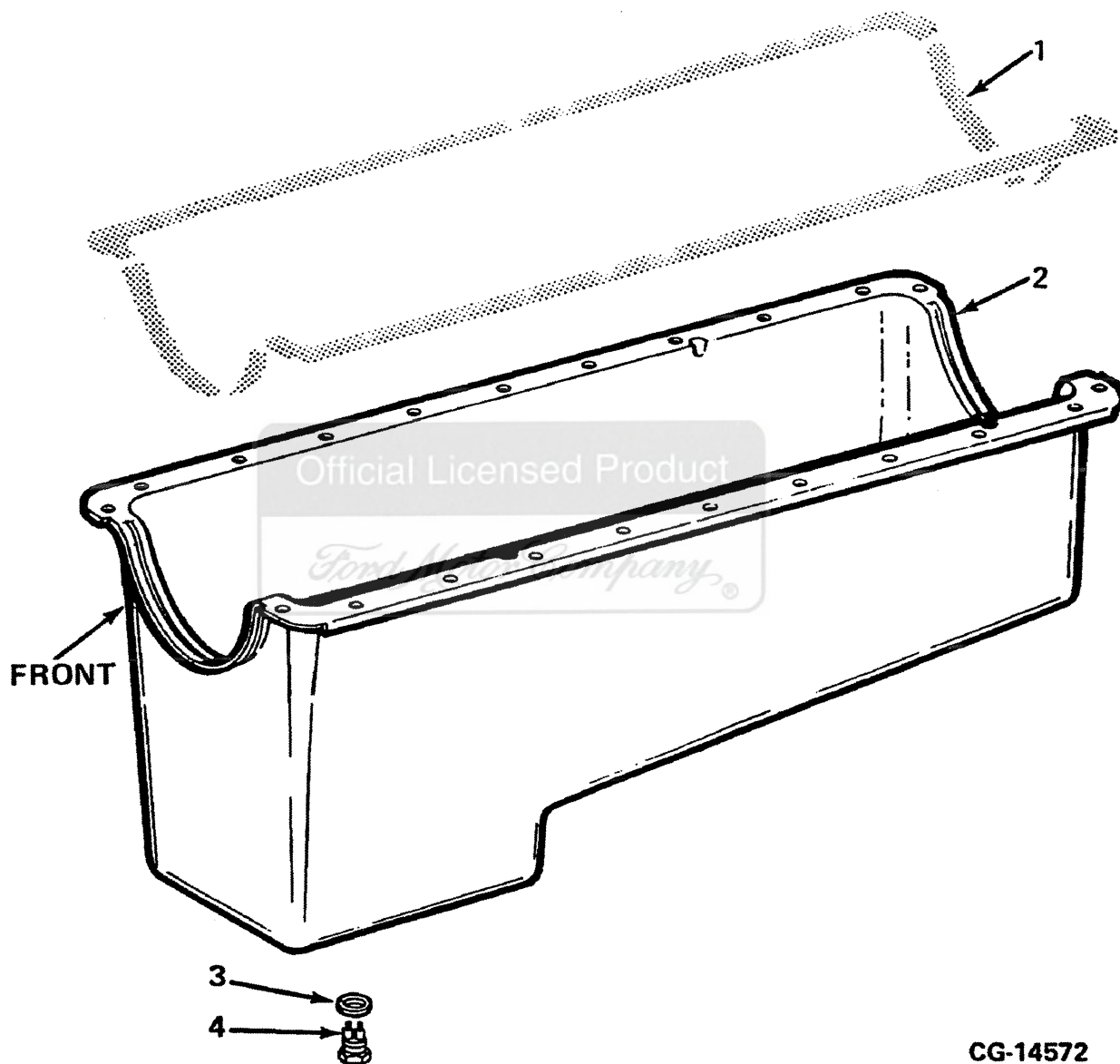
CG-12358

Figure 6.1. Crankshaft Assembly

- |   |   |
|---|---|
| 1. Pulley, Generator Drive                | 10. Crankshaft                              |
| 2. Bolt, Hex Head                         | 11. Gear, Flywheel Ring                     |
| 3. Washer, Crankshaft                     | 12. Flywheel                                |
| 4. Damper, Vibration                      | 13. Adapter, Flywheel (Auto. Trans. Only)   |
| 5. Pulley, Crankshaft                     | 14. Ring, Reinforcement (Auto. Trans. Only) |
| 6. Gear, Crankshaft                       | 15. Bolt, Special Flywheel                  |
| 7. Key, Woodruff                          | 16. Plate, Drive (Auto. Trans. Only)        |
| 8. Bearing, Crankshaft Nos. 1, 2, 4 and 5 | 17. Bolt, Pulley                            |
| 9. Bearing, Thrust No. 3                  |   |

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE



CG-14572

Figure 6.2. Oil Pan Assembly

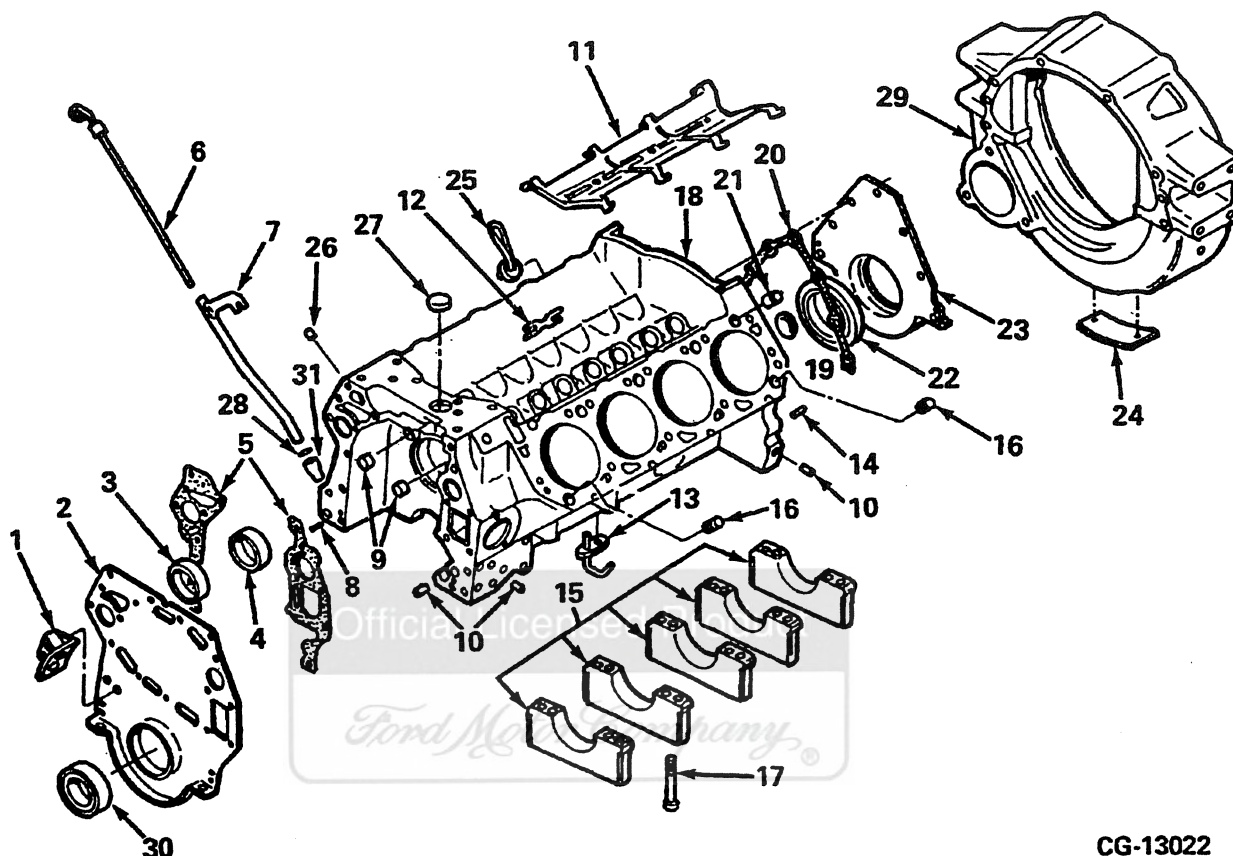
- 1. Oil Pan R.T.V. Sealant
- 2. Oil Pan

- 3. Drain Plug Gasket
- 4. Drain Plug (Magnetic)

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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Page 3



CG-13022

Figure 6.3. Crankcase Assembly

- |  |  |
|--|--|
| 1. Timing Indicator (Part of Front Cover)  | 18. Crankcase  |
| 2. Front Cover                             | 19. Expansion Plugs, Crankcase Rear                      |
| 3. Bushing, Camshaft Front                 | 20. Rear Cover Gasket                                    |
| 4. Bushing, Camshaft 2, 3, 4 & Rear        | 21. Dowel Sleeve, Cylinder Head Locating                 |
| 5. Front Cover Gaskets                     | 22. Rear Oil Seal  |
| 6. Oil Level Gauge                         | 23. Rear Plate, Crankcase                                |
| 7. Upper Oil Level Gauge Tube w/Bracket    | 24. Access Plate, Flywheel Housing                       |
| 8. Dowel Pin, Front Cover Locating         | 25. Heater, Crankcase                                    |
| 9. Cup Plug, Tappet Galleries              | 26. Ball 1 1/32", Alternate Dipstick Location Closing    |
| 10. Pipe Plug, Main Oil Gallery            | 27. Expansion Plug, Crankcase Top                        |
| 11. Guide Retainer, Hydraulic Valve Lifter | 28. O-Ring, Oil Level Gauge Tube (Except 130 HP Engines) |
| 12. Guide, Hydraulic Valve Lifter          | 29. Flywheel Housing                                     |
| 13. Piston Cooling Jet Tube (Bolt-On Type) | 30. Front Oil Seal                                       |
| 14. Dowel Pin, Rear Plate Locating         | 31. Lower Oil Level Gauge Tube                           |
| 15. Bearing Cap                            |  |
| 16. Cup Plug                               |  |
| 17. Bolt, Bearing Cap                      |  |



## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### SPECIFICATIONS

##### CRANKSHAFT:

Type .....	Steel Forging, Induction Hardened, Grindable
Main Bearing Journal Diameter	
• Standard Size .....	3.1228"-3.1236" (79.319-79.340 mm)
• .010" Undersize .....	3.1128"-3.1136" (79.065-79.085 mm)
• .020" Undersize .....	3.1028"-3.1036" (78.811-78.831 mm)
• .030" Undersize .....	3.0928"-3.0936" (78.557-78.577 mm)
Main Bearing Journal Max. Out-of-Round .....	0.0002" (0.005 mm)
Main Bearing Thrust Face Runout (TIR Max.) .....	0.001" (0.03 mm)
Main Bearing Journal Taper (Max./In.) .....	0.0005" (0.013 mm)
Main Journal Fillet Radius .....	0.121"-0.127" (3.07-3.22 mm)
Rod Journal Fillet Radius .....	0.120" (3.048 mm)
Oil Seal Journal Runout (Max.) .....	0.002" (0.05 mm)
Damper Mounting Area Runout (Max.) .....	0.001" (0.03 mm)
Flywheel Mounting Surface Runout (Max.) .....	0.002" (0.05 mm)
Number of Main Bearings .....	5
Thrust Taken By .....	Intermediate
Thrust Bearing Journal Length .....	1.1325"-1.1355" (28.766-28.841 mm)
Main Bearing I.D. (Installed) .....	3.1254"-3.1274" (79.385-79.436 mm)
Main Bearing to Crankshaft Clearance .....	0.0018"-0.0046" (0.046-0.117 mm)
Main and Rod Bearing Journal Finish .....	5-20 RMS
Main Bearing Thrust Face Finish .....	5-20 RMS
Connecting Rod Journal Diameter	
• Standard Size .....	2.498"-2.499" (63.45-63.47 mm)
• .010" Undersize .....	2.488"-2.489" (63.20-63.22 mm)
• .020" Undersize .....	2.478"-2.479" (62.94-62.96 mm)
• .030" Undersize .....	2.468"-2.469" (62.69-62.71 mm)
Connecting Rod Journal Max. Out-of-Round .....	0.0003" (0.008 mm)
Connecting Rod Journal Taper (Max./In.) .....	0.0005" (0.013 mm)
Connecting Rod Bearing to Crankshaft	
Running Clearance .....	0.0011"-0.0036" (0.028-0.091 mm)
Crankshaft Flange D.D. ....	3.748"-3.752" (95.199-95.300 mm)
Crankshaft End Play .....	0.0025"-0.0085" (0.063-0.215 mm)
Crankshaft End Play Max. Wear Limit .....	0.012" (0.304 mm)
Rod to Crankshaft Side Clearance .....	0.012"-0.024" (0.304-0.609 mm)
Crankshaft Straightness .....	0.002" (0.051 mm)
Crankshaft Gear Backlash .....	0.0015"-0.012" (0.038-0.30 mm)
Flywheel Runout .....	0.008" (0.20 mm)
Flywheel Concentricity .....	0.008" (0.20 mm)

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

Section 6  
Page 5

### SPECIFICATIONS

#### CRANKCASE:

Crankcase Deck Flatness	0.003" (0.076 mm) Overall
Crankcase Deck Finish (Micro Inches)	63-125
Crankcase Main Bearing Bore Diameter	3.3152"-3.3162" (84.21-84.23 mm)
Crankcase Cam Bearing Bore Diameter	2.2305"-2.2320" (56.65-56.69 mm)
Valve Lifter Bore Diameter	0.9228"-0.9243" (23.44-23.48 mm)
Valve Lifter O.D.	0.9209"-0.9217" (23.39-23.41 mm)
Oil Jet Tube Bore Diameter (Spray Hole Dia.)	0.052" (1.37 mm)
Cylinder Bore Diameter	
• Cylinder 1 thru 6	4.1095"-4.1115" (104.38-104.43 mm)
• Cylinder 7 and 8 Only	4.1100"-4.1120" (104.39-104.44 mm)
Cylinder Bore Taper (Top to Bottom)	0.003" Max.
Cylinder Bore Maximum Out-of-Round	0.002"
Cylinder Bore Surface Finish	15-30 RMS
Centerline of Main Bearing Bore to Head Deck	11.137"-1 1.141" (282.88-282.98 mm)
Oil Seals (Front and Rear Seal Face Runout)	
(with Plates Installed on Engine)	0.015" T.I.R. Max. (0.381 mm)
Main Bearings	
Type	Precision Replaceable
Material	Steel Backed Copper/Lead
Thrust Taken By	No. 3 Main
Cap Attachment	4 Bolts per Cap
Rear Plate Seal Bore Concentricity (T.I.R.)	0.020" (0.05 mm)

### SPECIAL TORQUES

Crankshaft Vibration Damper bolt	90 lbf.-ft. (122 N•m)
Flywheel Mounting Bolt (See Note 1)	47 lbf.-ft. (64 N•m)
Main Bearing Cap Bolt (See Note 2)	95 lbf.-ft. (129 N•m)
Oil Pan Drain Plug	28 lbf.-ft. (37 N•m)

**NOTE 1:** Apply Lock N' Seal(TM) (Part No. 577 588 C1) to all bolt threads prior to assembly.

**NOTE 2:** Tighten four main bearing cap bolts to 75 lbf.-ft. (102 N•m) before final torque is applied.

### SPECIAL SERVICE TOOLS

<u>Tool No.</u>	<u>Description</u>
SE-1897-69	Camshaft Bushing Remover and Installer
ZTSE-1900-69	Damper, Crankshaft and Camshaft Gear Installer
ZTSE-2295-69	Damper, Crankshaft and Camshaft Gear Remover
GBD4-1/8(†)	BRM Flex Hone®(†)
ZTSE-4130	Front Crankshaft Seal Installer
ZTSE-4131	Rear Crankshaft Seal Installer
ZTSE-1942-2A	Rear Crankshaft Seal Protector
ZTSE-4155A	Expansion Plug Replacer
SE-1632	Oil Leak Detector
SE-1399	Boring Machine
SE-1574	Cylinder Hone

(†)Order from: Brush Research Manufacturing Co., Inc.  
4642 East Floral Drive  
Los Angeles, CA 90022  
(213) 261-2193

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### FRONT OIL SEAL (Removal and Reassembly)

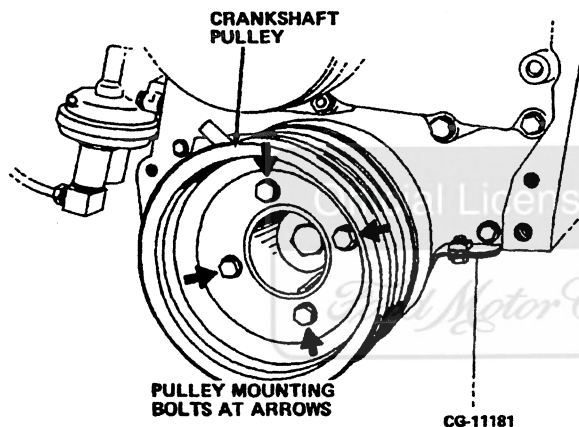
##### ■ Removal

Remove the following:

- Water Pump Pulley
- Water Pump
- Injection Pump Adapter Housing
- Oil Pan

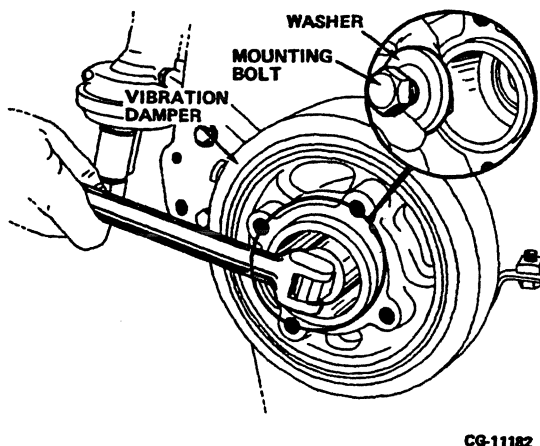
1. Remove bolts and lockwashers securing crankshaft pulley to damper. **Figure 6.4.**

**NOTE:** Pulley consists of two pieces.



**Figure 6.4. Crankshaft Pulley Removal**

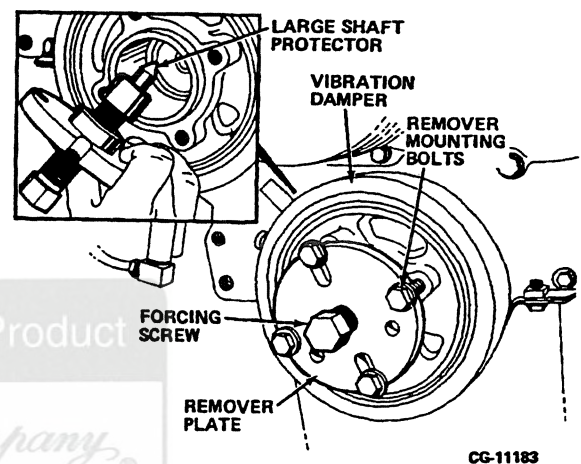
2. Remove crankshaft damper bolt and washer, **Figure 6.5.**



**Figure 6.5. Crankshaft Damper Removal**

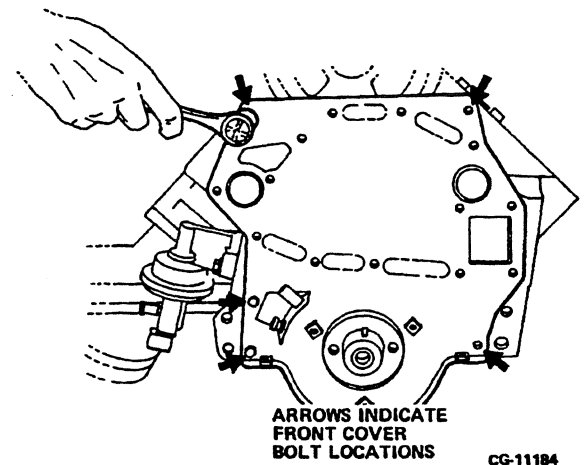
3. Remove crankshaft damper using damper, crank and cam gear remover ZTSE-2295-69, **Figure 6.6.**

- Attach remover ZTSE-2295-69 as shown, **Figure 6.6.**
- Be sure the large shaft protector is in place at the end of the forcing screw.
- Turn forcing screw (**Figure 6.6**) to remove damper.



**Figure 6.6. Using ZTSE-2295-69 to Remove Crankshaft Damper**

4. Remove the engine front cover mounting bolts and remove cover from the crankcase, **Figure 6.7.**



**Figure 6.7. Removal of Engine Front Cover**

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### FRONT OIL SEAL (Removal and Reassembly)

#### ■ Removal – Continued

5. Press front oil seal from front cover using a 3-1/4" O.D. disc, Figure 6.8.

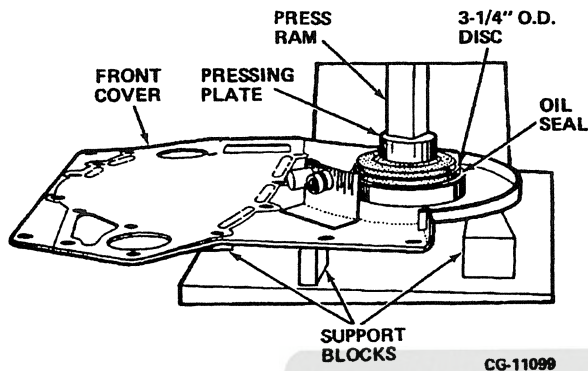


Figure 6.8. Front Cover Oil Seal Removal with Cover Removed Using 3-1/4" O.D. Disc

6. Discard oil seal.

#### ■ Reassembly

1. Coat I.D. of front cover with Aviation Permatex™ #3 and press new front oil seal in engine front cover using the front crankshaft seal installer ZTSE-4130 and support blocks (Figure 6.9). Install the oil seal flush to 0.010" below the front face of the front cover, Figure 6.10.

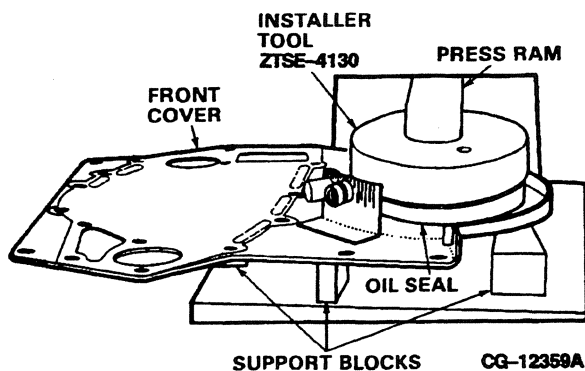


Figure 6.9. Pressing New Seal in Engine Front Cover Using Installer and Support Blocks

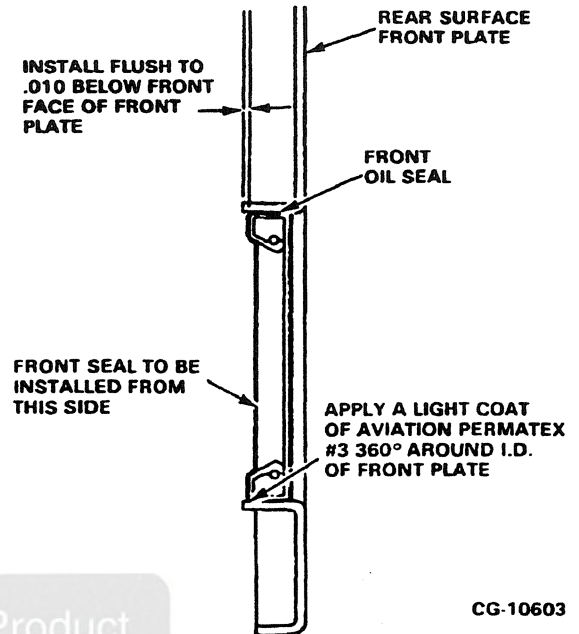


Figure 6.10. Front Oil Seal Installation

**NOTE:** The oil seal installer tool ZTSE-4130 will position the seal flush to 0.010" below the front face of the front cover automatically.

### FRONT OIL SEAL (Removal and Reassembly) (In Chassis)

#### ■ Removal

1. With crankshaft pulley and damper removed, use the crankshaft front oil seal remover tool (made locally), Figure 6.11.

**NOTE:** Construct tool following the dimensions provided in Figure 6.11.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

### FRONT OIL SEAL (Removal and Reassembly) (In Chassis)

#### ■ Removal - Continued

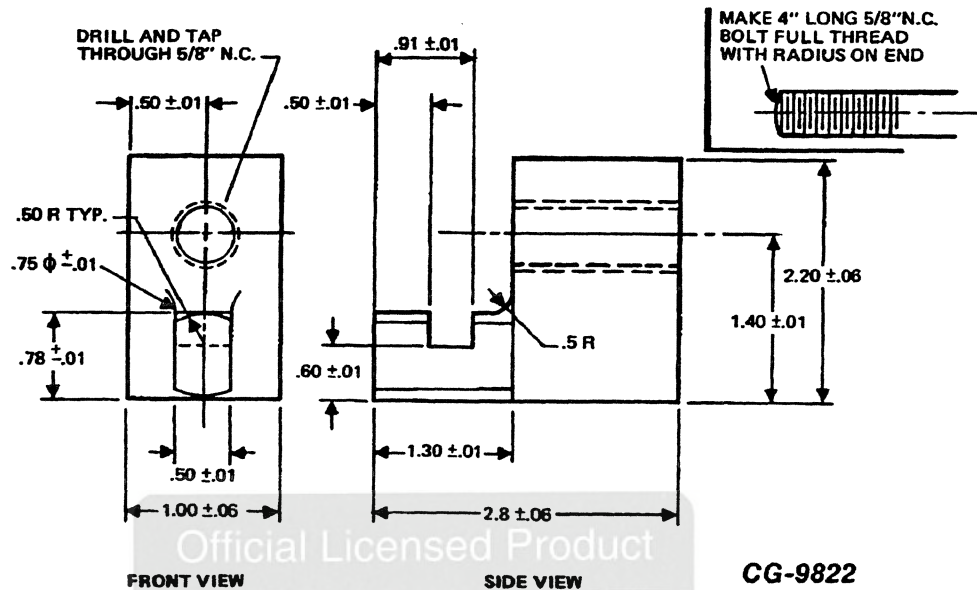


Figure 6.11. Crankshaft Front Oil Seal Remover (Made Locally)  
(For In Chassis Removal)

2. Use crankshaft front oil seal remover, Figure 6.12 as follows:

- Insert nose of remover tool under front seal by turning the remover tool with a wrench to position the nose under the seal lip. Refer to Figure 6.12.
- Tighten forcing screw (Figure 6.12) against front cover.
- Continue to tighten forcing screw to remove oil seal.

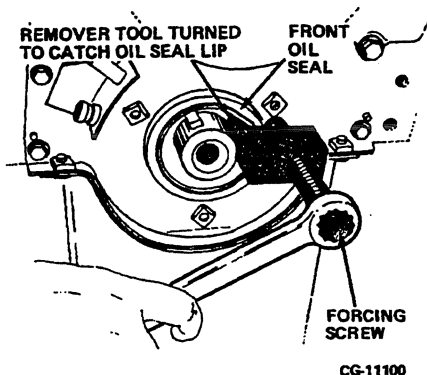


Figure 6.12. Removing Front Oil Seal Using Locally Made Tool

3. Discard old oil seal.

#### ■ Reassembly

- Coat the I.D. of the front cover bore with Aviation Permatex™ #3
- Position a new front oil seal onto the front crankcase seal installer body of ZTSE-4130, Figure 6.13.

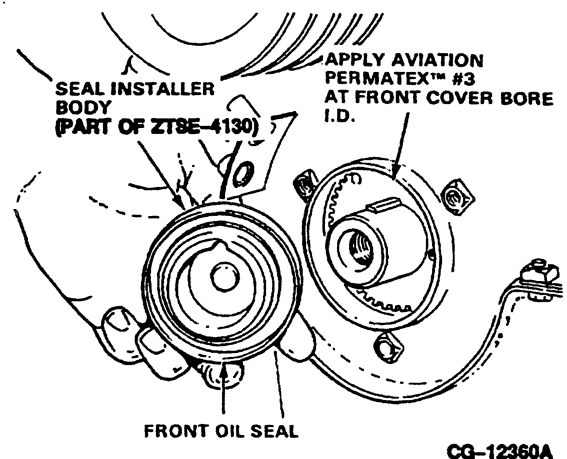


Figure 6.13. Oil Seal in Body of ZTSE-4130



# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### FRONT OIL SEAL (Removal and Reassembly) (In Chassis)

#### ■ Reassembly – Continued

3. Place the body of tool with crankshaft front oil seal over the end of the crankshaft.
4. Attach the bridge assembly to the engine front cover (Figure 6.14).
5. Position the square metal plate between the body and the bridge assembly. Make sure that the forcing screw tip engages the machined recess in the plate. Refer to Figure 6.14.
6. Turn the forcing screw until the body stops on the front cover to fully install the seal. Refer to Figure 6.14.

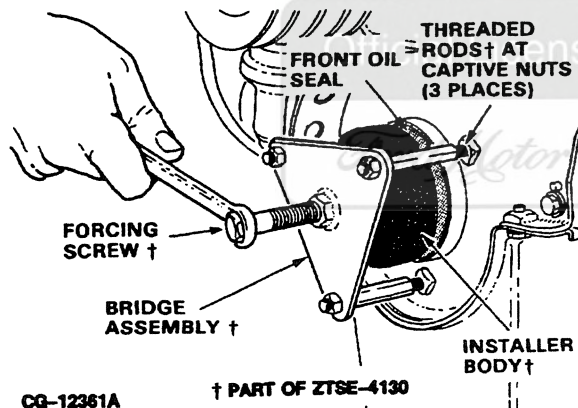


Figure 6.14. Installing Front Oil Seal

**NOTE:** Use of the installing tool ZTSE-4130 assures the front oil seal is installed to 0.010" below the front face of the front cover.

### REAR OIL SEAL (Removal and Reassembly)

#### ■ Removal

1. Remove nine mounting bolts and remove the flywheel assembly from the crankshaft flange. Refer to Figure 6.15 (manual transmission) and Figure 6.16 (automatic transmission).

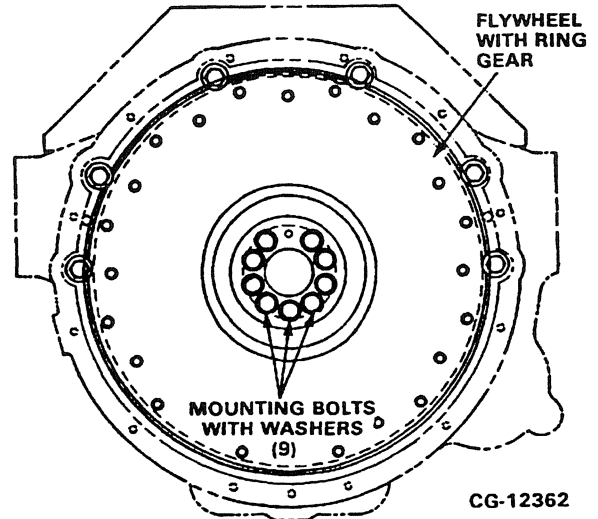


Figure 6.15. Flywheel Removal (Manual Transmission)

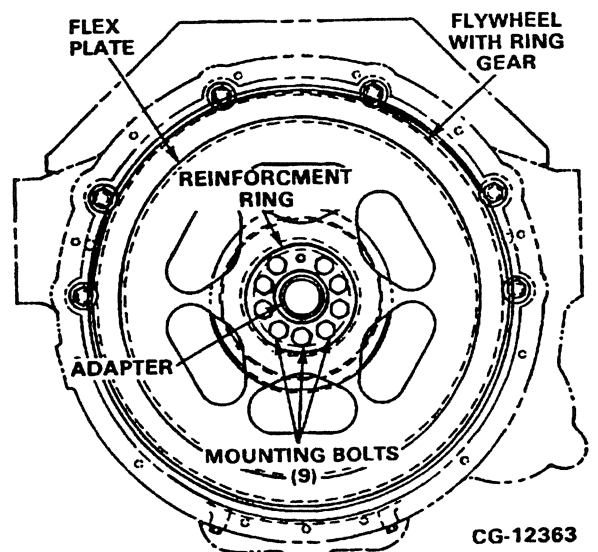


Figure 6.16. Flywheel Removal (Automatic Transmission)

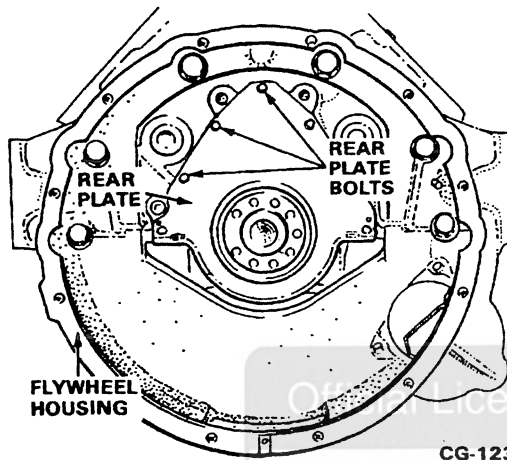
## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### REAR OIL SEAL (Removal and Reassembly)

##### ■ Removal – Continued

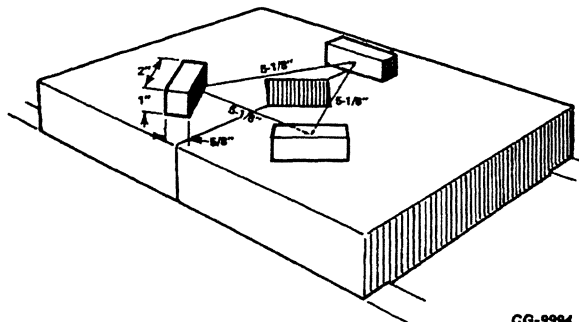
2. Remove rear plate bolts and remove rear plate with rear oil seal and gasket, **Figure 6.17**.



CG-12364

**Figure 6.17. Rear Plate and Oil Seal Removal**

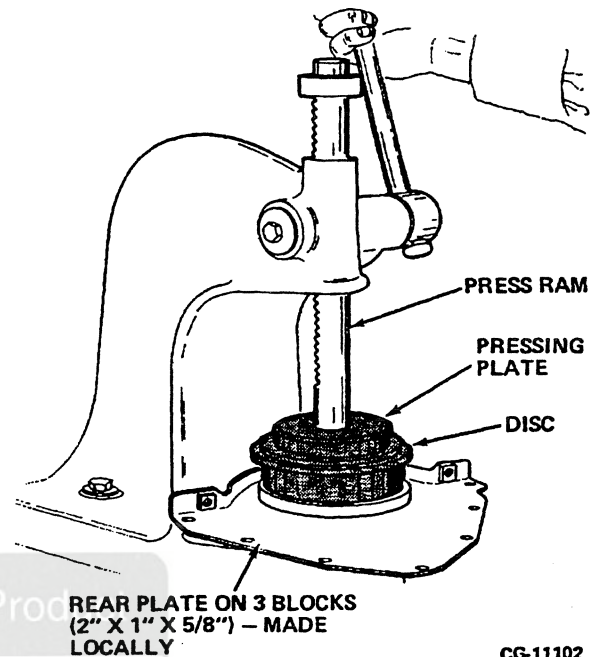
3. Place rear plate (**Figure 6.19**) on three (2" x 1" x 5/8") blocks spaced as shown in **Figure 6.18**.



CG-9994

**Figure 6.18. Block Arrangement on Arbor Press**

4. Choose an appropriate size disc and press seal from retainer plate as shown in **Figure 6.19**.
5. Discard old rear oil seal.



CG-11102

**Figure 6.19. Rear Oil Seal Removal**

##### ■ Cleaning and Inspection

1. Clean the crankcase and rear cover gasket surfaces of all foreign material. Scrape or wire brush R.T.V. sealant from the rear cover oil pan mating surfaces. Surfaces must be kept oil free for good adhesion of fresh R.T.V. sealant (during reassembly). Use a commercially available brake cleaner to clean the crankcase and rear cover gasket surfaces of oil. Wipe and dry with a clean shop cloth.

**NOTE:** Keep old R.T.V. from falling into the oil pan. It can block the oil pickup tube screen.

**NOTE:** If dowel pins (**Figure 6.20**) are damaged or missing, replace prior to verifying rear plate seal bore concentricity. If rear plate's dowel holes are damaged, replace with new.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### REAR OIL SEAL (Removal and Reassembly)

#### ■ Cleaning and Inspection – Continued

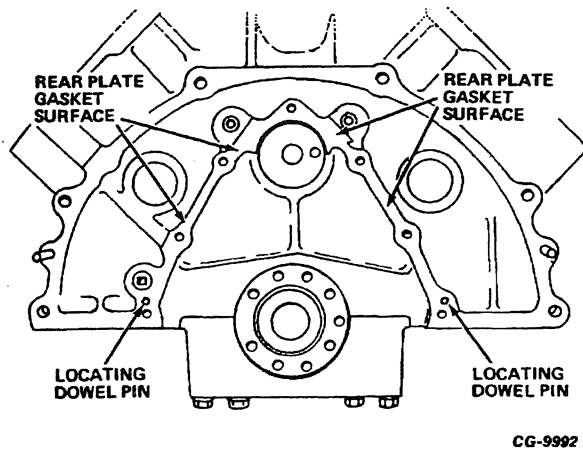


Figure 6.20. Locating Dowel Pins (Rear  
Cover to Crankcase)

2. Check rear cover seal bore concentricity, as follows; when confronted with a repeat failure:

- Install rear cover with oil seal removed.
- Mount a dial indicator with a swivel joint onto the crankshaft flange and position the dial indicator probe against the I.D. of the seal bore in the rear cover. See Figure 6.21.
- Measure at four (4) equally spaced locations.
- Seal bore in rear cover must be concentric to the crankshaft centerline per "SPECIFICATIONS".
- If **NOT** within specifications, replace the rear cover.

#### ■ Reassembly

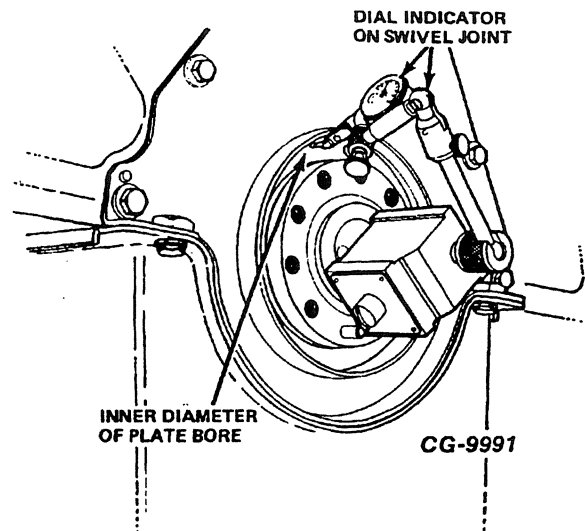


Figure 6.21. Measuring Rear Cover Bore  
Concentricity

3. Install new oil seal in (new or original) rear cover as follows:

### IMPORTANT

IF THE OPTIONAL REAR OIL SEAL AND WEAR SLEEVE PACKAGE (PART NO. 1 807 788 C92) IS USED, THE NEW "OVERSIZE" REAR OIL SEAL (INCLUDED IN THE PACKAGE) MUST BE INSTALLED. FOLLOW THE INSTRUCTIONS INCLUDED IN THE PACKAGE.

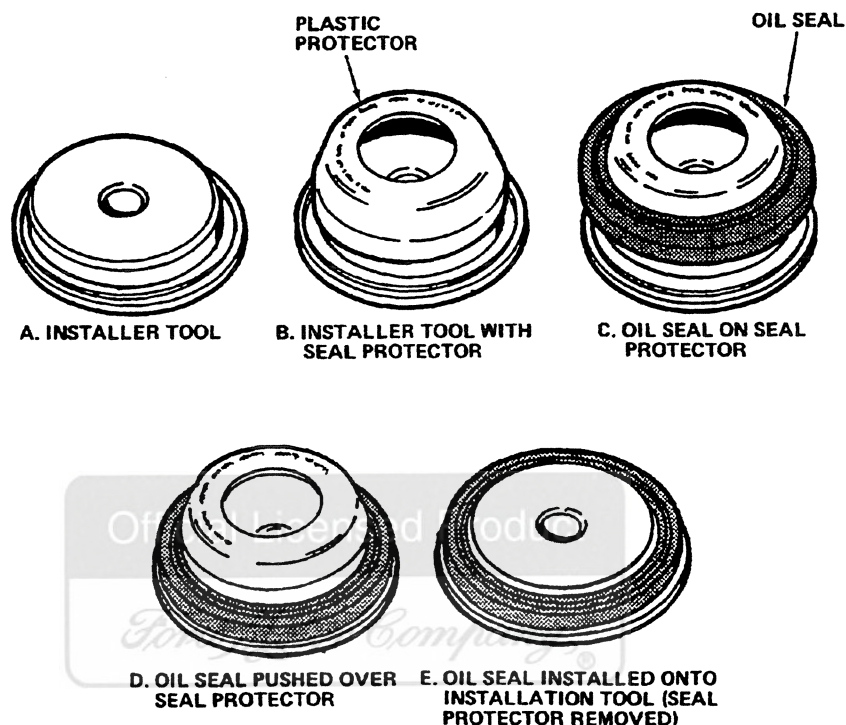
- Position seal protector tool ZTSE-1942-2A, onto installer tool ZTSE-4131 (Figure 6.22).
- Lubricate seal lip with clean engine oil.
- Press seal positioned as shown in Figure 6.22 over protector until it stops against installer tool. Remove protector from installer tool.
- Place 3, 1 inch high x 2 inch long x 5/8 inch wide metal blocks (made locally) on the bed of an arbor press, arranged as shown in Figure 6.23.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

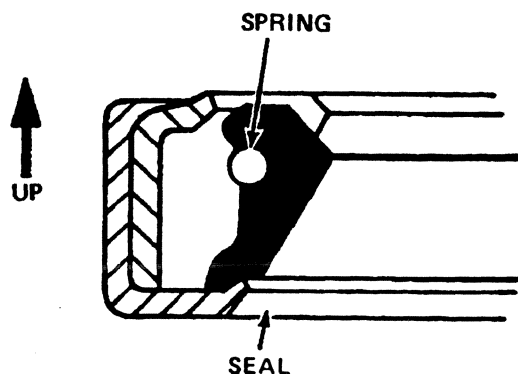
### REAR OIL SEAL (Removal and Reassembly)

#### ■ Reassembly – Continued

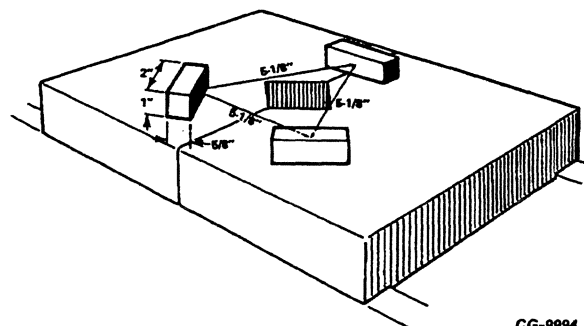


CG-11103

Figure 6.22. Installing Oil Seal Onto Installing Tool



CG-10647



CG-9994

Figure 6.23. Rear Oil Seal Position When  
Installing Onto Installer Tool

Figure 6.24. Block Arrangement on Arbor  
Press

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### REAR OIL SEAL (Removal and Reassembly)

#### ■ Reassembly - Continued

- e. Coat seal bore I.D. in rear cover with a thin coat of Aviation Permatex™ #3, as shown in Figure 6.25.

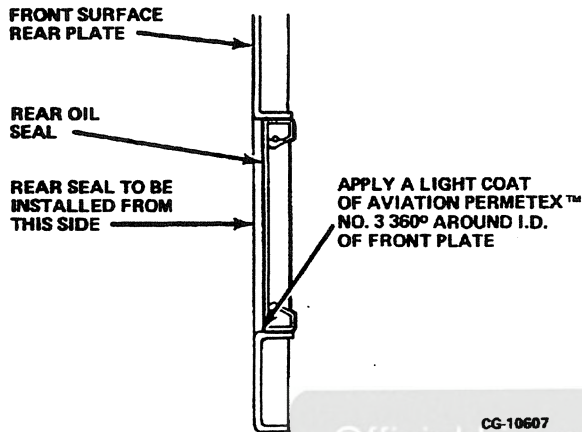


Figure 6.25. Location of Aviation Permatex™ #3 Sealant Application (Rear Oil Seal Installation)

- f. Place rear cover over blocks as shown in Figure 6.26 with press ram on installing tool. Press oil seal into rear cover bore until tool bottoms on plate.

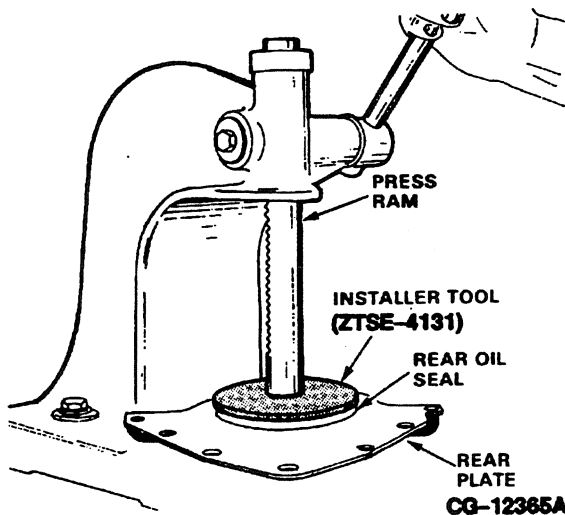


Figure 6.26. Pressing Rear Oil Seal into Rear Cover Bore Using Installer Tool (ZTSE-4131) and Arbor Press

### CRANKSHAFT (Reconditioning)

#### ■ Removal and Disassembly (For Engine Overhaul)

1. Remove the following components during engine overhaul, prior to crankshaft removal.

**NOTE:** Remove only those components with bullet points (●) when servicing the crankshaft (In chassis).

- |                          |                       |
|--------------------------|-----------------------|
| Injection Pump and Lines | ● Vibration Damper    |
| Intake Manifold          | Water Pump and Pulley |
| Exhaust Manifold         | Front Cover           |
| Oil Level Gauge Assembly | Rear Cover            |
| Cylinder Heads           | Pistons and Rods      |
| ● Flywheel               | ● Oil Pan and Pump    |
|                          | ● Glow Plugs          |

2. With crankshaft pulley, damper, front cover, flywheel assembly and rear cover removed as outlined earlier in this section, remove bolts from flywheel adapter and remove, Figure 6.27.

**NOTE:** In chassis's crankshaft removal does not require flywheel housing removal.

**NOTE:** Use extreme care when removing flywheel housing to prevent damaging the dowel pins.

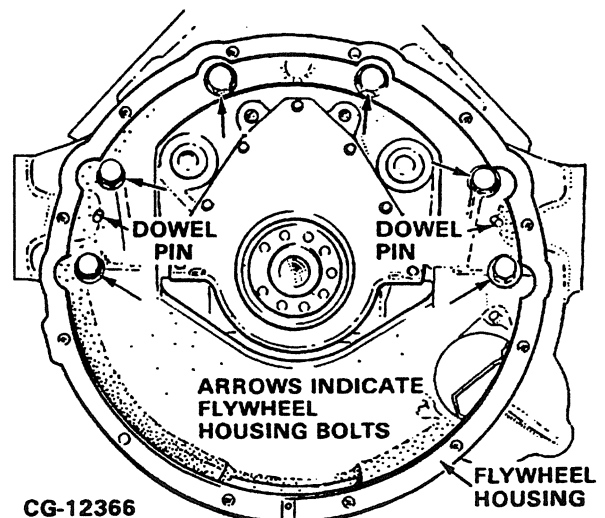


Figure 6.27. Flywheel Housing Removal



## SERVICE MANUAL

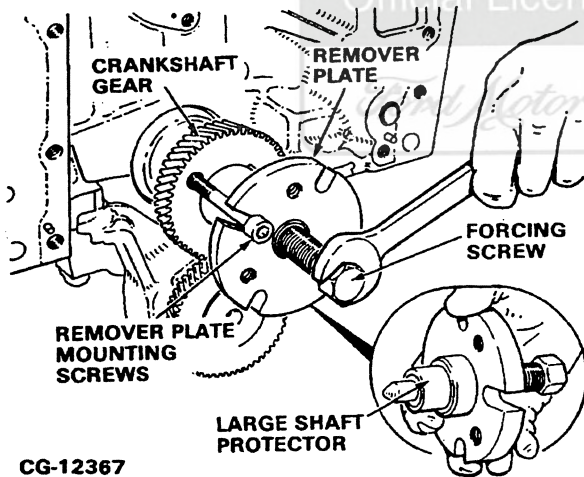
### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### CRANKSHAFT (Reconditioning)

##### ■ Removal and Disassembly (For Engine Overhaul) – Continued

3. Use ZTSE-2295-69, damper, crankshaft and cam gear remover to remove the crankshaft gear, **Figure 6.28**.

- Attach remover plate to the crank gear using two long cap screws threaded through the deep slots on the remover plate. Refer to **Figure 6.28**.
- Be sure the large shaft protector (**Figure 6.28**) is in place on the forcing screw.
- Turn the forcing screw to remove the gear.

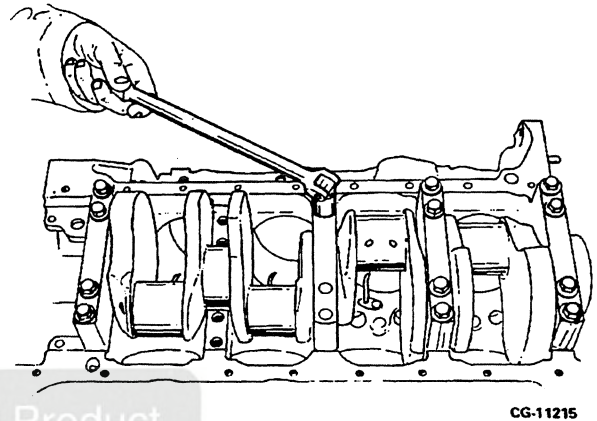


**Figure 6.28. Removing Crankshaft Gear Using ZTSE-2295-69**

**NOTE:** Crankshaft may be removed without removing the crankshaft gear.

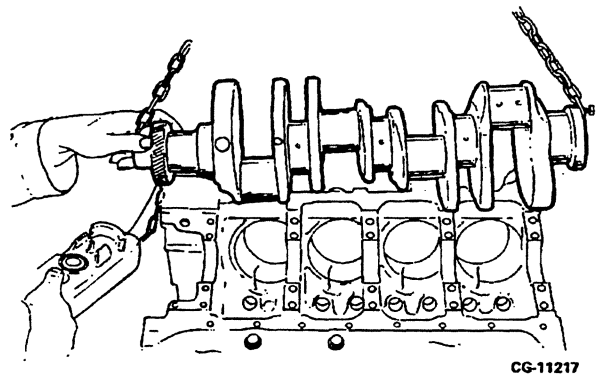
4. With oil pan, oil pump and oil pickup tube assembly removed, remove the bolts from the bearing caps and remove all main bearing caps, **Figure 6.29**. With bolts removed, rock the cap back and forth or tap with a plastic hammer.

**NOTE:** The crankshaft bearing caps are numbered from the front to identify their respective positions for reinstallation. The number 3 bearing cap accommodates a thrust flange to limit crankshaft end play.



**Figure 6.29. Main Bearing Cap Removal**

5. Attach lifting eyes to the crankshaft and lift the crankshaft straight up and out of the cylinder block, **Figure 6.30**.



**Figure 6.30. Crankshaft Removal**

6. With the crankshaft removed, remove the upper main bearing inserts.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### CRANKSHAFT (Reconditioning)

#### ■ Cleaning

1. Clean the crankshaft with a suitable solvent and dry with compressed air.

#### ■ Inspection and Repair

1. Visually inspect main bearing and connecting rod journals for scratches, grooves and scoring. Use dye penetrant methods to check for cracks.
2. Measure the diameter of each journal using a micrometer (see **SPECIFICATIONS**). Measure each journal at two points, at right angles to each other. Move the micrometer over the width of the journal. Check for out-of-round and taper (see **SPECIFICATIONS**).

**NOTE:** If the journals exceed the maximum out-of-round and/or taper specifications, the crankshaft must be reground or replaced.

#### ■ Crankshaft Grinding

1. The crankshaft can be ground 0.010 in., 0.020 in. or 0.030 in. undersize as follows:

**NOTE:** An induction hardened fillet and journal crankshaft can be reground similar to any precision crankshaft. However, these shafts require special treatment when grinding.

### IMPORTANT

**BEARING FAILURES CAN CAUSE OVERHEATING OF CRANKSHAFT JOURNALS AND A REDUCTION OF HARDNESS. WHEN THIS OCCURS, THE CRANKSHAFT STRENGTH MAY BE UNACCEPTABLY REDUCED. WHENEVER BLUING IS FOUND ON THE JOURNAL OR FILLET AREA, THE CRANKSHAFT MUST BE REPLACED.**

### IMPORTANT

**CRANKSHAFTS MUST NOT BE STRAIGHTENED. EVEN SLIGHT STRAIGHTENING WITH COMPLETE ABSENCE OF CRACKS WILL ENDANGER THE HIGH STRENGTH BUILT INTO THE SHAFT.**

**NOTE:** The superior strength of the crankshaft is due to the induction hardening process of the bearing journals and fillets. This localized hardening greatly increases the bending strength of the crankshaft; in order to maintain this strength, special precautions must be taken when regrounding the shaft. If special precautions are not taken, the crankshaft can be severely weakened. The metallurgical characteristics of the shaft demand exacting standards and control when regrounding journals. However, it can be reground locally where equipment and experience can produce quality standards outlined in the following instructions.

### IMPORTANT

**USE EVERY PRECAUTION TO AVOID BURNS ON THE SHAFT DURING THE GRINDING OPERATION.**

The crankshafts are reground similar to any precision crankshaft with the following precautions:

2. A mechanical or an automatic wheel dresser is mandatory to prevent chatter, burning and poor surface finish. A hand stone should **NEVER** be used to rough or fine dress the face or radii of the wheel. The radii should blend evenly into the journal.
3. The selection of the grinding wheel is important because too hard a wheel will increase the possibility of burning. An aluminum-oxide wheel with a grit size of approximately 50 and a maximum hardness of M will produce satisfactory results, with other conditions being suitable.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE


### CRANKSHAFT (Reconditioning)

#### ■ Crankshaft Grinding – Continued

4. The coolant must be such that it minimizes burning. This requires a fluid with high lubricity properties. The straight-cutting oils appear to be the best for grinding crankshafts and are strongly recommended.

5. A grinding wheel speed of 6500 surface feet per minute with a work spindle speed of approximately 40 to 45 revolutions per minute is usually satisfactory.

6. Grind all journals with crankshaft rotating in a counterclockwise direction (viewed from front of crankshaft), lap all journals with crankshaft rotating in clockwise direction. **DO NOT RE-FINISH REAR SEAL FLANGE.**



**CAUTION**

**It is a good practice to keep a type ABC fire extinguisher near any grinding equipment which cools with oil and produces heat.**

Feed rates should be slower than normal to prevent any burning.

7. Inspection of the crankshaft for dimensional tolerances is the same as for conventionally hardened crankshafts, except that extra care must be taken to be sure the shaft is cool before inspecting.

8. In addition to inspecting the dimensional tolerances, the crankshaft must also be carefully checked for surface defects, particularly for grinding cracks and burns. It is advisable to spray check the crankshaft (using dye penetrant methods) after grinding and lapping to insure that there is no surface cracking.

#### ■ Crankshaft Undersize Grinding Limits

Grinding Limits:

1. Maximum allowable taper on crankpins (rod journals) and main journals .00015 per inch of length (.013 mm per 25.4 mm) of length. Crankpins and journals must be polished to 20

Micro-inch maximum – to 5 Micro-inch minimum, and must not be over 0.0003 inch (0.003 mm) out of round.

2. The main journal fillet radii should be .121-.127" (3.07 – 3.226 mm) with the crankpins (rod journals) fillet radii held at .120" (3.05 mm).

3. The third main journal controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. For this reason the width of the third journal must be 1.1325 – 1.1355 in. (28.765 – 28.842 mm).

### GRINDING LIMITS CHART

PRODUCTION SIZE	
Main Journal	3.1228–3.1236 in. (79.319–79.340 mm)
Crankpin (rod journal)	2.498–2.499 in. (63.45–63.47 mm)
.010 INCH UNDERSIZE	
Main Journal	3.1128–3.1136 in. (79.065–79.085 mm)
Crankpin (rod journal)	2.488–2.489 in. (63.20–63.22 mm)
.020 INCH UNDERSIZE	
Main Journal	3.1028–3.1036 in. (78.811–78.831 mm)
Crankpin (rod journal)	2.476–2.478 in. (62.94–62.87 mm)
.030 INCH UNDERSIZE	
Main Journal	3.0928–3.0936 in. (78.557–78.577 mm)
Crankpin (rod journal)	2.468–2.469 in. (62.69–62.71 mm)

**TARASOV ETCH:** In order to establish the acceptability of a regrind procedure, equipment and operator, the first reground crankshafts should be etched before lapping to determine whether the crankshaft was burned during the regrinding cycle. The best etch to use is the Tarasov etch, which will show both the rehardened and the over-tempered areas. The etching procedure is as follows:



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## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### CRANKSHAFT (Reconditioning)

#### ■ Crankshaft Undersize Grinding Limits- Continued



#### CAUTION

Due to the sharp odor and flammability of the Tarasov etch, the etching should be done in a well-ventilated area, away from any open flame.

- Clean surface with a scouring powder and water or a good solvent.
- Wash thoroughly and rinse with alcohol.
- Apply etchant No. 1 (4 parts nitric acid in 96 parts water) for approximately 16 seconds with a cotton swab.
- Rinse with water and dry.
- Apply etchant No. 2 (2 parts hydrochloric acid in 98 parts acetone) for approximately 15 seconds with a cotton swab.



#### CAUTION

Acetone is highly flammable

- Rinse with alcohol and dry thoroughly with compressed air.

If the crankshaft has been burned, it will show up as a change of color after the etch. Areas re-hardened by excessive heat appear nearly white, while softened areas turn dark gray or black. Areas unaffected by the heat of grinding etch a light gray.

#### IMPORTANT

IF ANY BURNS SHOW UP AFTER THE ETCH IS USED, THE PHYSICAL PROPERTIES OF THE CRANKSHAFT WILL HAVE BEEN SERIOUSLY REDUCED, AND THE CRANKSHAFT SHOULD NOT BE USED.

NOTE: If burning becomes a serious problem, it can usually be eliminated by reducing the infeed rate, using a softer grade of wheel, or increasing the work spindle speed. Sometimes, a combination of these factors, along with the recommendations mentioned above, will be necessary to overcome the problem.

- After the crankshaft passes the Tarasov etch test, it may be lapped.

#### IMPORTANT

THOROUGHLY CLEAN THE CRANKSHAFT OIL PASSAGES WITH A NYLON BRISTLE BRUSH, SOAP AND WATER TO REMOVE ALL DEBRIS WHICH MAY HAVE ACCUMULATED DURING THE REGRINDING PROCEDURE. ANY DEBRIS LEFT IN THE CRANKSHAFT OIL PASSAGES CANNOT BE REMOVED BY THE OIL FILTERS AND WILL DAMAGE BEARINGS IMMEDIATELY UPON ENGINE START-UP. ONCE CLEANED, WRAP THE CRANKSHAFT, TO PROTECT IT FROM CONTAMINATION, UNTIL IT IS INSTALLED.

#### IMPORTANT

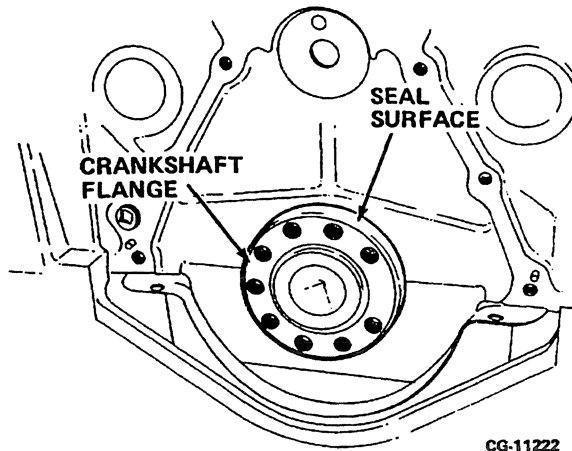
VISUALLY INSPECT THE SEAL SURFACE ON THE CRANKSHAFT FLANGE FOR NICKS, ETC. THE SEAL WITNESS MARK (FIGURE 6.31) ON THE CRANKSHAFT FLANGE SHOULD BE CONTINUOUS AND UNBROKEN. IF THE CONDITION OF THE FLANGE SURFACE IS QUESTIONABLE, INSTALL THE OPTIONAL CRANKSHAFT WEAR SLEEVE AND REAR OIL SEAL PACKAGE (P/N 1 807 788 C92). FOLLOW THE INSTALLATION INSTRUCTIONS INCLUDED WITH THE PACKAGE.

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### CRANKSHAFT (Reconditioning)

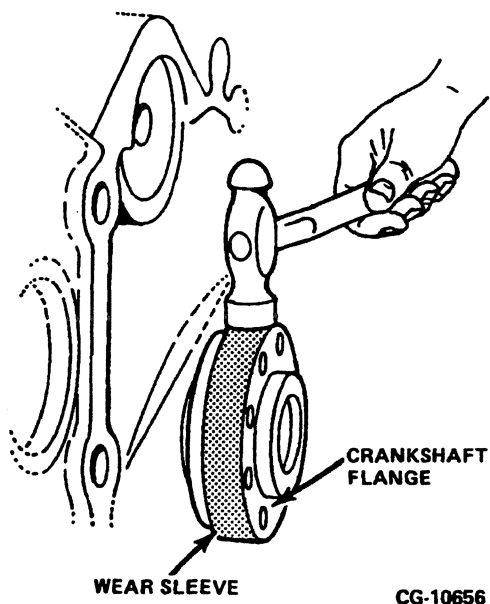
##### ■ Crankshaft Flange Inspection and Repair



**Figure 6.31. Inspecting Crankshaft Flange Seal Surface**

1. If crankshaft flange has been previously fitted with an optional wear sleeve from Rear Oil Seal and Wear Sleeve Package (P/N 1 807 788 C92), remove the wear sleeve by carefully "tapping" with a hammer (Figure 6.32),

**NOTE:** Be careful not to damage the crankshaft flange face or O.D.



**Figure 6.32. Crankshaft Wear Sleeve Removal**

##### ■ Installation

**NOTE:** Prior to crankshaft installation, inspect crankcase as outlined later in this section.

1. Using a lint-free cloth, wipe the bearing supports of the crankcase free of oil.
2. Clean the bearing inserts and caps thoroughly in solvent and dry with compressed air. **DO NOT SCRAPE GUM OR VARNISH DEPOSITS FROM BEARING SHELLS.**
3. Visually inspect each bearing. Replace bearings that are scored, chipped or worn.
4. Check bearing clearance as follows:
  - a. Install the bearing halves into the crankcase. Be sure locking tangs on the bearings are snapped into the crankcase saddle and the oil holes in the bearing shells line up with the oil holes in the crankcase.
  - b. Carefully install the crankshaft into the crankshaft bearing saddle.
  - c. Install bearing halves with cap and tighten the inner and outer bolts to the specified torque.
  - d. Remove one bearing cap and insert one at a time. Remaining caps are left tight while checking the fit of the bearing with the cap removed.
  - e. Wipe the oil from all contact surfaces of the exposed journal, bearing insert and cap.
  - f. Place a piece of Plastigage® across the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately 1/4 in. off center. Install bearing cap and tighten cap bolt to "specified" torque.

**NOTE:** Do not turn crankshaft while making check with Plastigage®.

**NOTE:** IN CHASSIS SERVICE ONLY – When bearing clearance is checked, the crankshaft will have to be supported and held against the upper main bearing halves to get a correct Plastigage® reading. Use a jack at the counterweight next to each main bearing being checked to support the crankshaft. Failure to support the crankshaft will result in inaccurate readings.



# SERVICE MANUAL

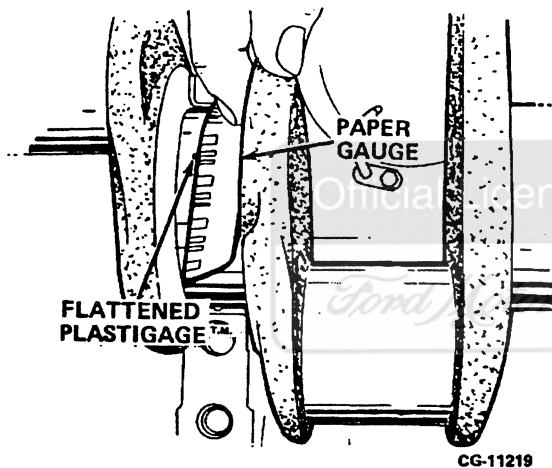
## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### CRANKSHAFT (Reconditioning)

#### ■ Installation – Continued

- g. Remove bearing cap and insert.
- h. Do not disturb Plastigage®. Using the Plastigage® envelope, measure the widest point of the Plastigage®, **Figure 6.33**. This reading indicates the bearing clearance in thousandths of an inch or millimeters.
- i. If the bearing clearance is not within specifications, the crankshaft must be re-ground and undersize bearings installed (as described earlier in this section).



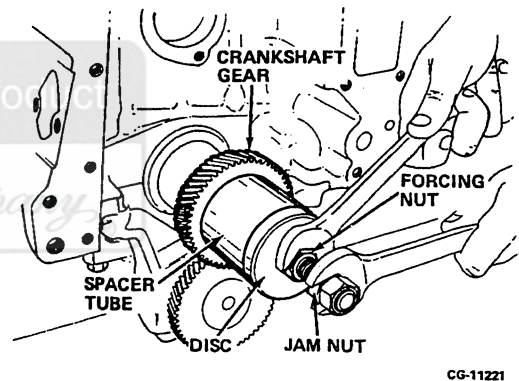
**Figure 6.33. Checking Main Bearing Clearance**

5. When acceptable bearing clearance is achieved with either old or new parts, proceed as follows:

- a. Clean Plastigage® from the bearing or crankshaft journal surface.
- b. Coat all bearing surface journals and bolts with clean engine oil.
- c. Place the bearing caps and bearing lower halves over the crankshaft. Be sure the bearing caps are properly installed. Number 1 is in the front position.
- d. The bearing caps can be only put on one way. Finger-tighten the bearing caps. Using a soft hammer, tap the number 1, 2 and 4 bearing caps until the rear machined faces of the caps are flush with the machined faces of the crankcase.

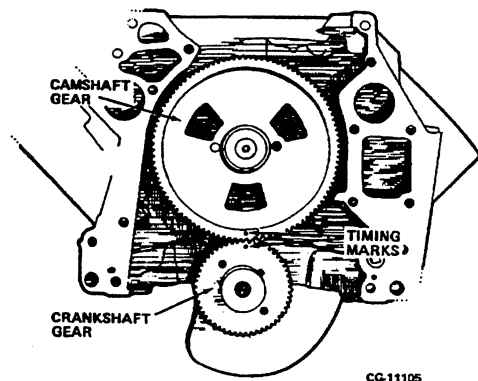
e. Repeat the same operation for bearing cap number 5 only aligning the front face of the cap with the crankcase. The number 3 bearing rear thrust flanges must be flush with each other. Aligning caps in this manner will assure proper cap location. Check this alignment at both sides (left and right) of the bearing caps. Tighten the main bearing cap bolts to specified torque.

f. Install crankshaft gear (IF REMOVED), using ZTSE-1900-69 damper, crankshaft and camshaft gear installer, **Figure 6.34**. Assemble the spacer tube, disc, thrust washer and nut onto the end of the crankshaft. Turn the nut on the installer ZTSE-1900-69 to install the crankshaft gear.



**Figure 6.34. Installing Crankshaft Gear with Installer and Adapter ZTSE-1900-69**

6. Align the timing marks of both the camshaft and crankshaft gears as shown in **Figure 6.35**.



**Figure 6.35. Aligning Timing Marks on Camshaft and Crankshaft Gears**

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### CRANKSHAFT (Reconditioning)

##### ■ Installation – Continued

7. The thrust bearing (No. 3 Main Bearing) provides the initial location of the crankshaft in relation to the crankcase. Check crankshaft end play using a dial indicator as follows: (Refer to **Figure 6.36.**)

- Mount the dial indicator on the crankcase with the indicator tip on the crankcase flange face.
- With all bearing caps (except No. 3 thrust bearing) tightened to specified torque and No. 3 thrust bearing finger-tight, adjust end play by prying the crankshaft forward and backward.

- Tighten the thrust bearing to the specified torque and "zero" the dial indicator.

- Check the end play by moving the crankshaft back and forth using a pry bar while reading the dial indicator.

If end play exceeds specification, replace the thrust bearing. If the end play is less than the minimum limit, the thrust bearing faces are damaged or dirty. If not damaged or dirty they were probably misaligned. After inspection either clean, replace or install the thrust bearing and align the faces following the bearing installation procedure in this section. Recheck crankshaft end play.

8. Rotate the crankshaft and camshaft to verify that the gears do not bind or interfere. With the use of a dial indicator, **Figure 6.37**, check the gear backlash (see **SPECIFICATIONS**). If backlash limits are exceeded, timing gears should be replaced.

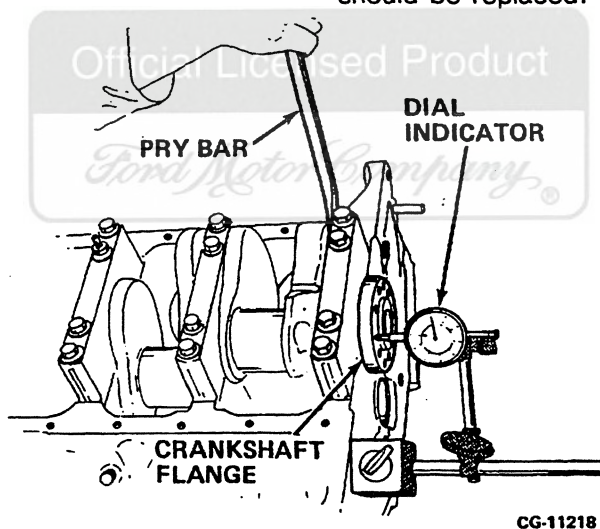


Figure 6.36. Checking Crankshaft End Play

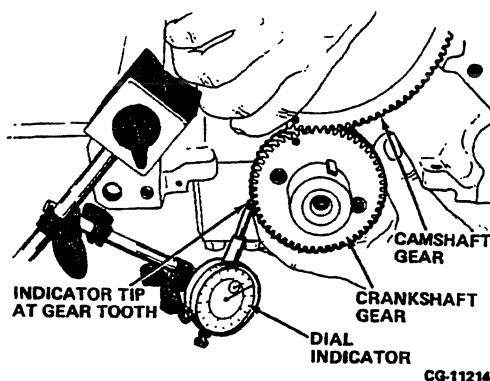


Figure 6.37. Checking Camshaft and Crankshaft Gear Backlash

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### PISTON COOLING JET TUBES (Removal and Reassembly)

#### ■ Removal

1. Remove each piston cooling tube (Figure 6.38) by removing the retaining bolt. **NOTE:** The retaining bolts are special "patch type" bolts, **DO NOT** substitute.

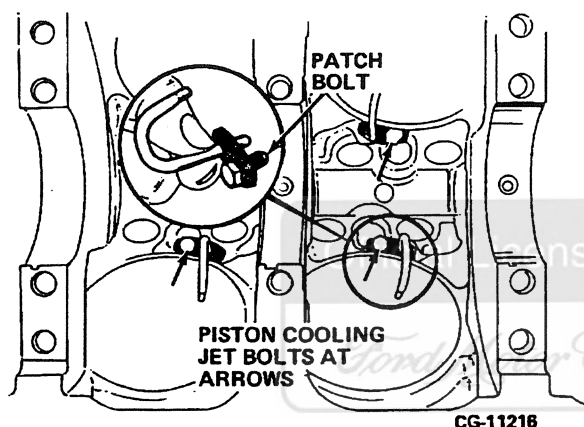


Figure 6.38. Piston Cooling Jet Removal

#### ■ Cleaning and Inspection

1. With cooling jet tubes removed, run an appropriate size wire through the tube to assure there is no blockage.
2. Blow out debris using filtered compressed air.

#### ■ Installation

1. Place jet tube assembly onto the crankcase mounting pad.
2. Tighten the special patch bolt to standard torque.
3. **DO NOT** substitute bolts, use only the specified 1/4"-20 x 5/8" "patch type" bolts.
4. Bolt on piston cooling jet tubes are self aligning.

### OIL LEVEL GAUGE TUBE (Removal and Reassembly)

#### ■ Removal (Refer to Figure 6.39)

1. Remove the 5/16" nut and washer which secures the upper oil level gauge tube with bracket, at the exhaust manifold.
2. Remove the upper oil level gauge tube assembly from the crankcase at the lower tube. Remove the sealing O-ring and discard.

#### ■ Cleaning

1. Thoroughly clean the lower tube.
2. Dry thoroughly.

**NOTE:** If the lower oil level gauge tube must be replaced, remove the tube by driving it out of the crankcase with a 5/16" x 3" bolt. Thoroughly clean the crankcase mating surface. Apply a small bead of Loctite 601 around the outer circumference of the lower tube. Press the new lower tube into the crankcase, as shown in Figure 6.39.

#### ■ Reassembly

1. Install a new O-ring onto the upper tube and insert the upper tube assembly in the lower tube.
2. Fasten the bracket onto the right exhaust manifold stud bolt, using the previously removed nut and washer. Tighten to standard torque.

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### OIL LEVEL GAUGE TUBE (Removal and Reassembly) - Continued

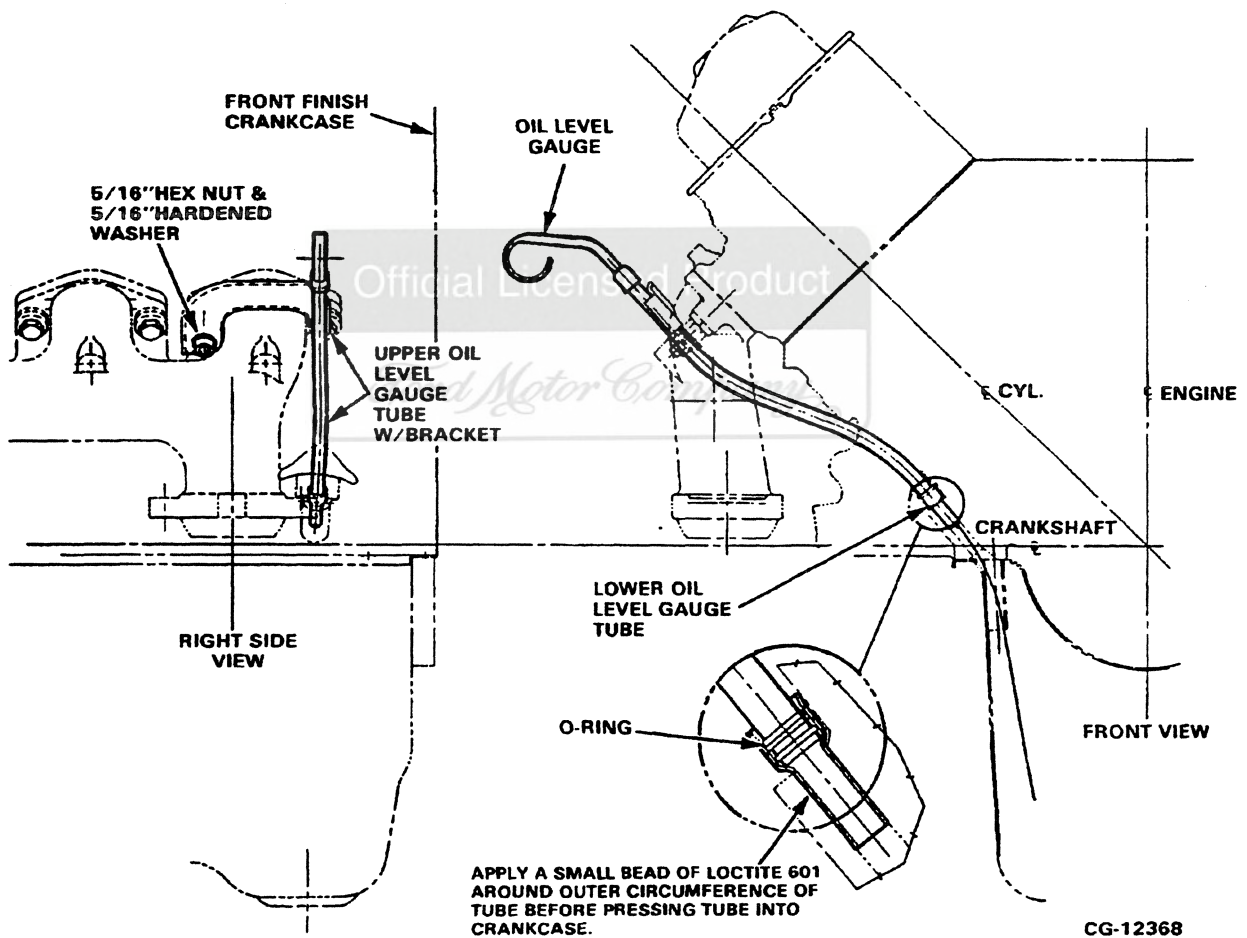


Figure 6.39. Oil Level Gauge Tube Assembly (Removal & Reassembly)



# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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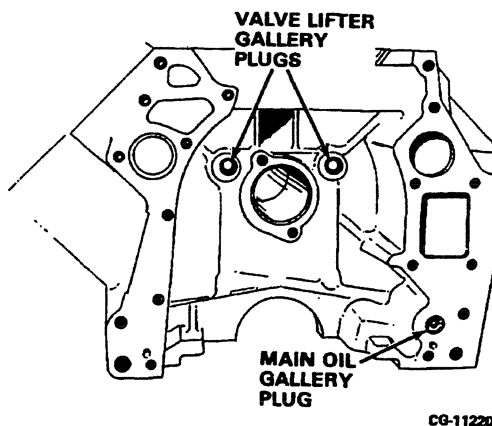
### CRANKCASE (Reconditioning) IMPORTANT

#### IMPORTANT

**THOROUGHLY CLEAN AND INSPECT  
THE CRANKCASE BEFORE AND AFTER  
RECONDITIONING.**

#### ■ Cleaning

1. Clean all old gasket material from the machined surfaces of the crankcase, using a scraper. Clean the cylinder bore using soap, water and a nylon brush.
2. Remove the pipe plugs (located in the rear of the crankcase) which seal the oil passages and thoroughly clean all passages and bolt holes.
3. Remove the main oil gallery plug and use a nylon brush (3/8" dia.) to clean the main oil gallery, **Figure 6.40**. Replace oil plug after coating with Aviation Permatex™ No. 3.



**Figure 6.40. Cleaning Main Oil Gallery with  
Nylon Brush**

4. Remove the valve lifter oil gallery plugs (located in the front of the crankcase) by drilling a small hole in the plug and prying with a screwdriver. Clean the valve lifter oil galleries with a nylon brush (5/16" dia.). Replace the valve lifter gallery plugs flush to 9.060" (1.52 mm) below the crankcase surface, then stake.

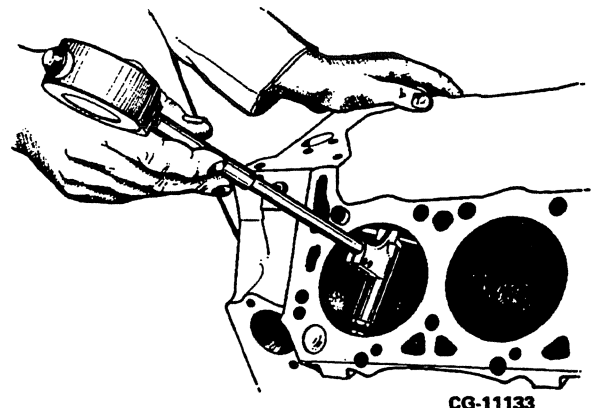
**NOTE:** Use Aviation Permatex™ No. 3 prior to installing the main and valve lifter oil gallery plugs.

#### IMPORTANT

**THREADS IN CRANKCASE BOLT  
HOLES MUST BE CLEAN AND  
BLOWN DRY WITH FILTERED  
COMPRESSED AIR.. DIRT OR OIL  
IN HOLES MAY CAUSE BINDING  
AND/OR FALSE TORQUE READING  
DURING REASSEMBLY.**

#### ■ Inspection and Repair

1. Visually inspect crankcase, after cleaning, for scoring, roughness or wear at the cylinder bores. Also check for cracks or water leaks.
2. Check for cracks using a spray dye penetrant method of crack detection. (A 3 step method: cleaner, dye and developer).
  - Replace the crankcase if cracked; do not attempt to weld.
3. Check the top surface of the crankcase for flatness. Using a straightedge, check by attempting to insert a .003" feeler gauge ribbon between the straightedge and crankcase head surface. **IF THIS IS POSSIBLE, REPLACE THE CRANKCASE.**
4. Check cylinder bore out-of-round and taper using an accurate dial bore gauge as shown in **Figure 6.41**.



**Figure 6.41. Checking Cylinder Bore Using  
Dial Bore Gauge**



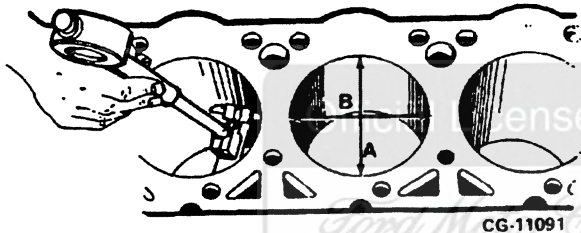
## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### CRANKCASE (Reconditioning)

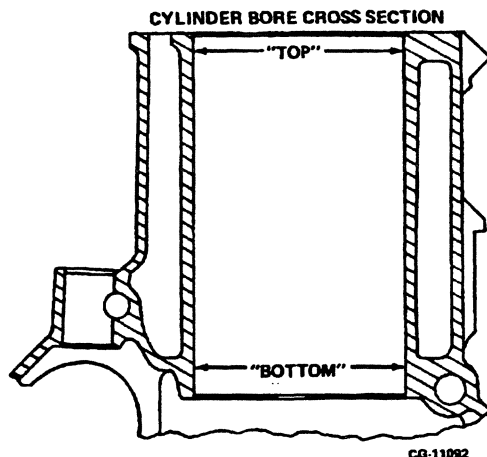
##### ■ Inspection and Repair – Continued

5. Measure the diameter of the cylinder bore at the top of the piston ring travel at a right angle "A", **Figure 6.42** to the centerline of the crankshaft. Record the readings. Next, measure each bore so the gauge reading coincides with the centerline "B", **Figure 6.42** of the crankshaft. Record that reading. The difference between "A" and "B" is the out-of-round condition at the top of the cylinder bore. Repeat the same procedure at the bottom of the ring travel to check for out-of-round condition. (See **SPECIFICATIONS**).



**Figure 6.42. Checking Cylinder Bore Out-of-Round**

6. With the reading recorded in step 5, determine the taper of the bore by determining the difference between the diameters measured at the "top" and "bottom" of the bore as shown in the **Figure 6.43**. (See **SPECIFICATIONS**).



**Figure 6.43. Checking Cylinder Bore Taper**

**NOTE:** To determine taper, use measurements made at right angles to the centerline of the crankshaft.

7. If the cylinder bore is within the specifications, use new standard size pistons and rings. Refer to Section 5.

**NOTE:** Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceeds specifications.

If cylinder walls have minor surface damage, but out-of-round and taper are within limits, it may be possible to remove such damage by honing cylinder walls and installing new service pistons, providing piston clearance is within specified limits. Refer to Section 5.

If cylinder bore is suitable for use without reconditioning, deglaze the bore using glaze breaker brush then reassemble.

#### IMPORTANT

**IF THE CYLINDER BORES ARE TO BE DEGLAZED, THE PISTON COOLING JET TUBES MUST BE REMOVED.**

#### • Deglazing

8. Cylinder bore can be deglazed using a 120 grit (no color code) glaze breaker brush such as the BRM Flex Hone® (see Note) GBD4-1/8. (Refer to **Figure 6.44**).

**NOTE:** Order the BRM Flex Hone® GBD4-1/8 directly from:

**Brush Research Manufacturing Co., Inc.**  
4642 East Floral Drive  
Los Angeles, CA 90022  
(213)261-2193

This Silicone carbide-tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall surface in a single operation. The brush contours itself to the cylinder wall and conditions the wall surface without altering the cylinder bore.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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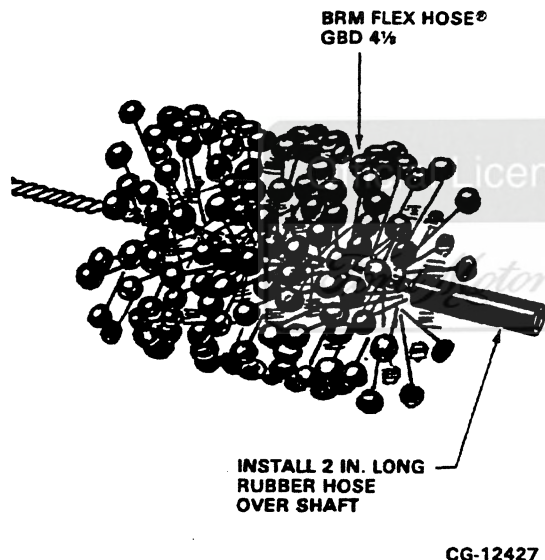
### CRANKCASE (Reconditioning)

#### ■ Inspection and Repair – Continued

#### ● Deglazing – Continued

9. It is NOT necessary to remove the crankshaft prior to deglazing the cylinder walls; however, it is good practice to insert a hose of suitable length and diameter over the BRM Flex Hone® shaft to protect the crankshaft. Refer to Figure 6.44.

**NOTE:** It is good practice to rotate the crankshaft, prior to deglazing, so the journal is at its lowest point in the bore.



**Figure 6.44. BRM Flex Hone® with Rubber Hose**

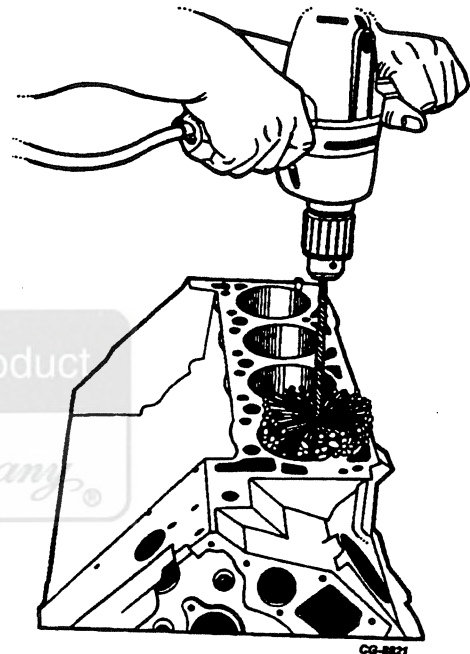
10. Obtain a 12 oz. can of PE-12 "Solvent and Penetrating Fluid" manufactured by AGS, available at any well-stocked auto supply house. This spray contains colloidal graphite and has a black appearance. Spray both the cylinder to be deglazed and the flex hone.

11. Deglaze the cylinder as follows: (Refer to Figure 6.44A.)

- Attach the flex hone to an electric or air powered drill **WITH ADJUSTABLE SPEED.**

### IMPORTANT

A SPEED OF APPROXIMATELY 100-200 RPM IS REQUIRED. SPEED ADJUSTMENT IS REQUIRED FOR THE PROCEDURE TO BE SUCCESSFUL.



**Figure 6.44A. Deglazing Cylinder Wall Surface Using GBD 4-1/8 BRM Flex Hone® with an Adjustable Speed Drill**

- Hone the cylinder wall for about 3 seconds while stroking up and down at a rate of one up and down stroke per second.
- Withdraw the flex hone from the cylinder bore while the hone is rotating. Wipe a portion of the cylinder wall and visually inspect the crosshatch pattern comparing it to an untouched cylinder bore. (Refer to Figure 6.45.)

**NOTE:** The crosshatch pattern should be approximately 45°. Visual comparison with a "virgin" bore is best, provided the engine has not been previously repaired.

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### CRANKCASE (Reconditioning)

##### ■ Inspection and Repair – Continued

##### ● Deglazing – Continued

d. If the pattern is "flatter" than required, increase the up and down stroke speed or slow down the drill rotation.

e. Continue deglazing the cylinder bore (after adjusting your technique) for an additional 10–15 seconds (approximately 20–25 strokes).

#### IMPORTANT

**DURING THE DEGLAZING, AN ASSISTANT MUST CONTINUALLY SPRAY THE PE-12 "SOLVENT AND PENETRATING FLUID", BY AGS, ONTO THE CYLINDER WALL.**

f. Wipe the cylinder bore clean and once again visually inspect the bore for the proper 45° crosshatch pattern. (Refer to Figure 6.45.)



CG-5370

Figure 6.45. Finish on the Cylinder Wall

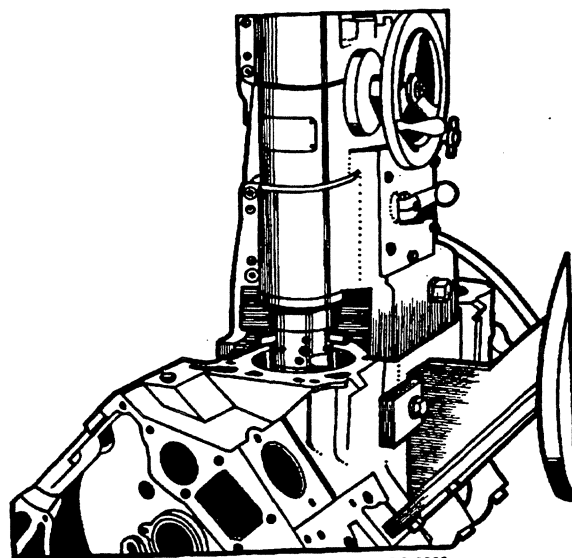
12. After deglazing, thoroughly clean the cylinder bores using soap and water, dry with filtered compressed air and re-oil using clean engine oil.

##### ● Reboring Cylinder Bore

13. However, if the wear exceeds the taper and out-of-round limits, it is recommended to rebore the cylinder or cylinders to within 0.003" of the required oversize diameter, Figure 6.46. This will allow enough stock for the final step of honing the bores, Figure 6.47, so that the exact clearance may be obtained for the selected oversize piston. When performing the honing operation, the hone should be stroked up and down to produce a crosshatch pattern on the cylinder wall as shown in Figure 6.45. The faster the hone rotates, the faster it must be stroked up and down to produce the desired crosshatch pattern.

#### IMPORTANT

**PISTON COOLING JET TUBES MUST BE REMOVED FOR REBORING AND HONING OPERATIONS.**



CG-8820

Figure 6.46. Reboring Cylinder Using Boring Machine (SE-1399)

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### CRANKCASE (Reconditioning)

- Inspection and Repair – Continued
- Reboring Cylinder Bore – Continued

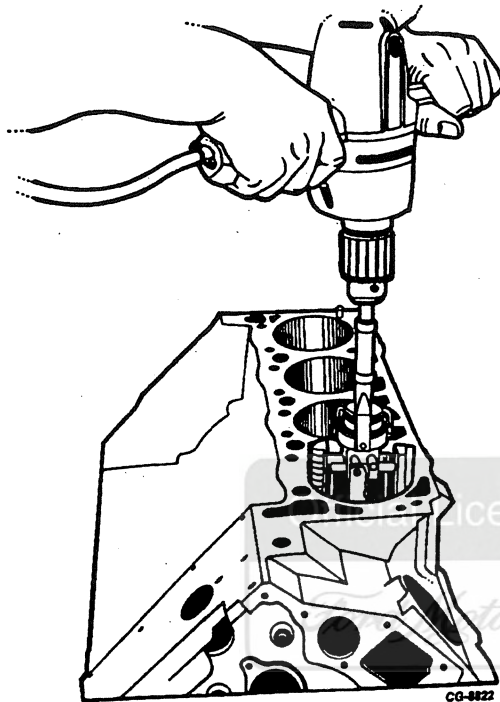


Figure 6.47. Honing Cylinder Bore Using Appropriate Cylinder Hone (SE-1574)

**NOTE:** After the honing operation is completed, the sharp burred edge that develops at the top and bottom of a newly honed cylinder should be removed manually with emery cloth. Then thoroughly clean the block and cylinder bores.

14. After the honing operation is completed, thoroughly clean the cylinder bores using soap and water. Dry with filtered compressed air and re-oil using clean engine oil.

**NOTE:** Failure to properly clean the cylinder bores can result in rapid engine wear and piston ring failure.

#### ● Expansion Plugs

15. If it becomes necessary to remove an expansion plug due to water leaks, drill a 1/2" hole in the center of the plug and remove by prying with a small pry bar.

16. Install the new expansion plugs with the concave side toward the engine. Coat the edges of the plug with Aviation Permatex™ No. 3. Use expansion plug replacer ZTSE-4155A which consists of a driver and driver sleeve which accurately indents the expansion plugs upon striking with a hammer.

**NOTE:** With crankcase disassembled, inspect the camshaft bushings and service as described in Section 4.

### FLYWHEEL (Reconditioning)

#### ● MANUAL AND AUTOMATIC TRANSMISSION

##### ■ Cleaning

1. Clean with a non-caustic solvent, then visually inspect the flywheel for cracks, heat checks and extensive scoring which would make it unfit for further service. Replace as required.

##### ■ Inspection

2. Inspect the ring gear for worn, chipped or cracked teeth. If teeth are damaged, replace the ring gear as follows:

#### ● RING GEAR REMOVAL

a. Heat the ring gear with a torch on the engine side of the gear.

b. Once heated, knock it off the flywheel. **DO NOT HIT THE FLYWHEEL WHEN REMOVING THE RING GEAR.**

#### ● MANUAL TRANSMISSION ONLY

##### ■ Repair

1. The flywheel may be ground to correct minor wear and scoring. Do not remove more than 0.060 in. (1.524 mm) of stock from the original thickness of 1.480 ± 0.010 in. (37.59 ± .254 mm).

2. Do not grind beyond the minimum permissible thickness of 1.410 in. Replace the flywheel if not repairable by surface grinding. Refer to **Figure 6.48.**



## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### FLYWHEEL (Reconditioning)

- MANUAL TRANSMISSION ONLY -

Continued

- Repair - Continued

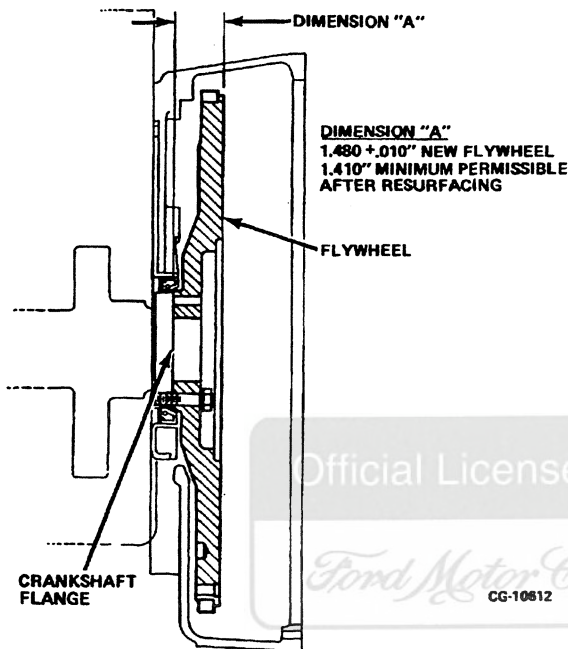


Figure 6.48. Flywheel Surface Grinder  
Specifications for Manual Transmission Only

#### CAUTION



This flywheel resurfacing information is provided for guidance only. Navistar International Transportation Corp. assumes no responsibility either for the results of any work performed in accordance with this information or for the ability of service personnel to detect heat cracks. Any crack or heat check in the flywheel could cause it to separate, creating the possibility of injury to the operator or bystanders. Carefully examine the flywheel, after resurfacing, for any cracks or heat checks. If there is any question, do not use the flywheel.

- MANUAL AND AUTOMATIC TRANSMISSION

#### ■ Installation (Rear Cover Assembly and Flywheel)

1. If new ring gear is required, heat the new ring gear evenly until the gear expands enough to slip onto the flywheel. Make sure the gear is sealed properly against the shoulder. Do not heat any portion of the gear to a temperature higher than 500°F (278°C). If this limit is exceeded, the hardness will be removed from the ring gear teeth.

2. Install the rear cover with rear oil seal installed (as described earlier in this section) as follows:

#### IMPORTANT

SEAL PROTECTOR SHOWN IN FIGURE 6.49 IS FOR STANDARD SIZE REAR OIL SEAL INSTALLATION. WHEN INSTALLING OPTIONAL OVERSIZED REAR OIL SEAL, USE PROTECTOR INCLUDED IN WEAR SLEEVE PACKAGE (P/N 1 807 788 C92). REFER TO INSTRUCTIONS INCLUDED WITH WEAR SLEEVE PACKAGE.

- Apply a thin coat of Aviation Permatex™ #3 to crankcase cover gasket surface as shown in Figure 6.49. Install rear cover gasket. Repeat above application of sealant on gasket. **DO NOT ALLOW PERMATEX TO GET ON CRANKSHAFT OIL SEAL FLANGE.**

#### IMPORTANT

**DO NOT GET ANY AVIATION PERMATEX™ #3 SEALANT ON THE SEAL LIP.**



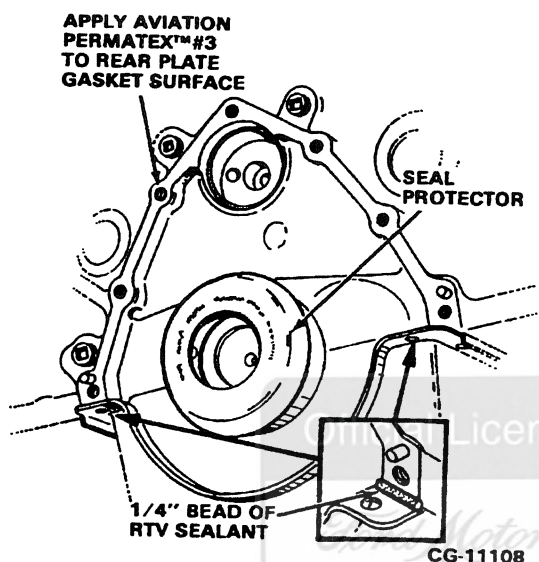
# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### FLYWHEEL (Reconditioning)

#### ■ Installation (Rear Cover Assembly and Flywheel) – Continued

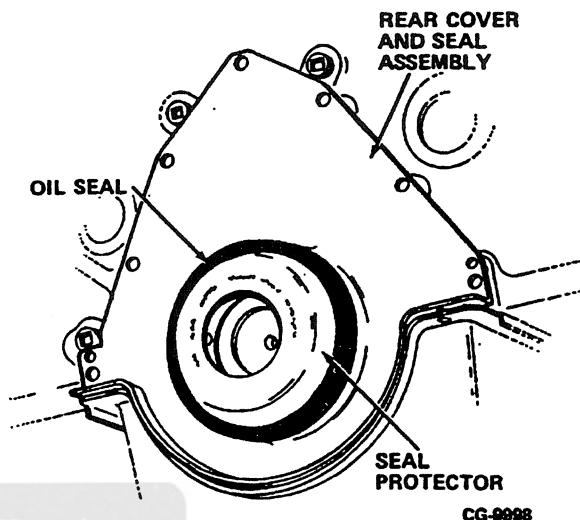


**Figure 6.49.** Location of Aviation Permatex™ #3 for Rear Cover Gasket; and Seal Protector Installed Over Crankshaft Flange

b. With appropriate seal protector installed over crankshaft flange to protect the seal lip, coat the seal lip with a thin film of clean engine oil.

c. Install rear cover and seal assembly over seal protector as shown in **Figure 6.50**. Remove seal protector after rear cover and seal assembly installation. Tighten all bolts to standard torque.

**NOTE:** Apply an additional 1/4 in. bead of R.T.V. sealant in 2 places as shown in **Figure 6.49**, prior to rear cover and seal installation.



**Figure 6.50.– Installing Rear Plate and Seal Assembly**

**NOTE:** Apply R.T.V. sealant (Dow 732 or GE Silmate 1473) to oil pan surface as follows:

If Oil Pan is Removed:

- 1/8 in. dia. bead for side rails as shown in **Figure 6.63**.
- 1/4 in. dia. bead for corners, front and rear ends as shown in **Figure 6.63**. Corners have double bead.

If Oil Pan is Not Removed:

- 1/4 in. dia. bead for front corners as shown in **Figure 6.49**.

### IMPORTANT

**ASSEMBLE PARTS WITHIN 10  
MINUTES OF APPLICATION OF  
R.T.V. TO COMPONENTS.**

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

### FLYWHEEL (Reconditioning)

#### ■ Installation (Rear Cover Assembly and Flywheel) – Continued

3. With the rear cover and seal assembly in place check seal run-out as follows: (Refer to Figure 6.51.)

- Position a magnetic base dial indicator on the end of the crankshaft flange.
- Place the indicator against the rear surface of the seal body at the 12 o'clock position. Remove crankshaft end play by pushing (or pulling) against the crankshaft and "zero" the dial indicator.
- Bar the engine over and take a reading at four (4) points, approximately 90° apart.
- Crankshaft seal run-out should not exceed specified run-out.

### IMPORTANT

NEVER TAKE AN INDICATOR READING WITH THE INDICATOR PROBE RESTING ON LETTERS OR NUMBERS WHICH APPEAR ON THE REAR SURFACE OF THE SEAL.

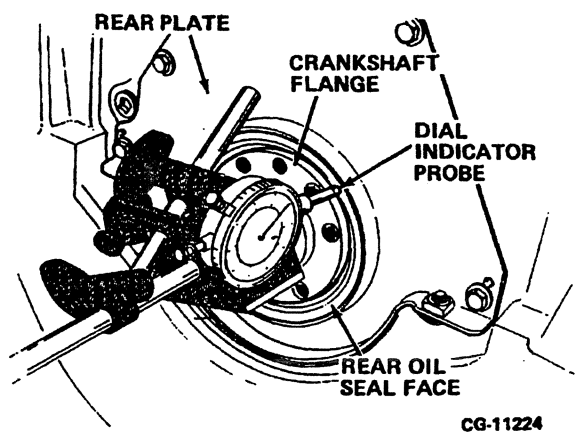
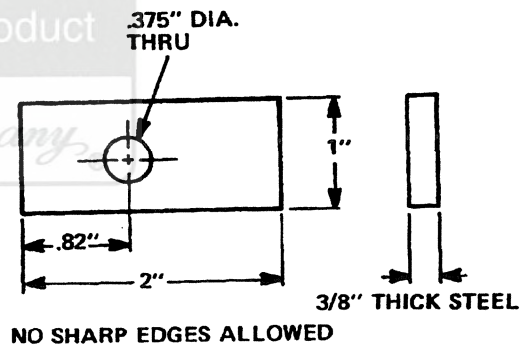


Figure 6.51. Measuring Rear Crankshaft Oil Seal Run-Out

4. If rear crankshaft oil seal run-out exceeds specifications, adjust the seal as follows: (Refer to Figure 6.56.) (Note location of seal which protrudes out the farthest.)

a. It is recommended that a pressing plate be fabricated as specified in Figure 6.52 and used in conjunction with an SAE No. 16 woodruff key, 3/8" cap screw and washer as follows:

- Install fabricated tool (Figure 6.52) using the 3/8 in. bolt and washer onto the crankshaft flange bolt hole nearest the seal area which protrudes. Insert SAE No.16 woodruff key under the fabricated tool as shown in Figure 6.53.
- Gently tighten the bolt against the seal to depress the area of the seal which exceeds the run-out specification.
- After adjustment, measure rear crankshaft seal run-out to assure specified run-out.
- Repeat if necessary.



NO SHARP EDGES ALLOWED

CG-10519

Figure 6.52. Pressing Plate Fabrication Specifications (Made Locally)

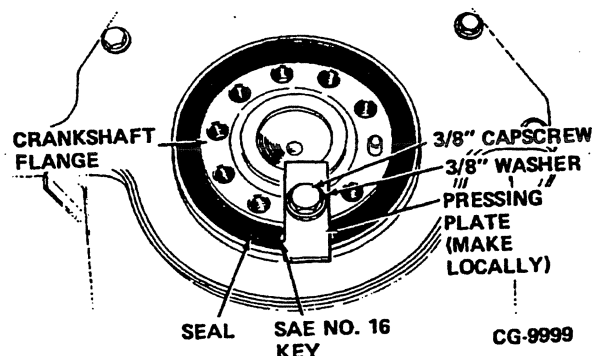


Figure 6.53. Crankshaft Rear Oil Seal Adjustment

# SERVICE MANUAL

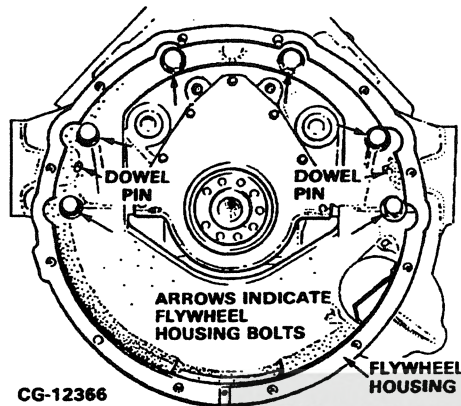
## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### FLYWHEEL (Reconditioning)

#### ■ Installation (Rear Cover Assembly and Flywheel) - Continued

5. Install the flywheel housing (if removed), using the six mounting bolts and hardened washers. Refer to **Figure 6.54**. Tighten to standard torque.



**Figure 6.54. Flywheel Housing Installation**

6. Install flywheel as follows:

#### MANUAL TRANSMISSIONS:

Apply Lock N' Seal™ (P/N 577 588 C1) to all nine mounting bolts and tighten to specified torque.

#### AUTOMATIC TRANSMISSIONS:

a. **Engine Ser. No.s' 848 166 and Below:** If reinstalling original mounting bolts apply Lock N' Seal™ (P/N 577 588 C1) to all nine mounting bolts and tighten to specified torque.

If new mounting bolts are being installed refer to Step b below.

b. **All Engines w/Automatic Transmissions:** When installing new flywheel mounting bolts for the first time, check mounting bolt thread color. Six to eight threads should be silver color.

This silver color is a pre-applied sealant and **DOES NOT** require the application of additional sealant to the threads.

However, each time mounting bolt is removed to service flywheel apply Lock N' Seal™ (P/N 577 588 C1) to the clean bolt threads before reinstalling bolt and tighten to specified torque.

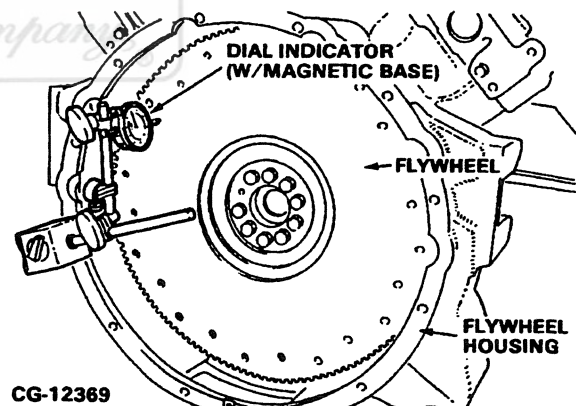
7. With the flywheel installed on the crankshaft, check flywheel face and ring gear run-out as follows:

a. For flywheel face run-out, install a dial indicator so the indicator point bears against the flywheel face, one inch in from the edge of the flywheel, **Figure 6.55**. For checking ring gear run-out, install the dial indicator point on the face of the ring gear adjacent to the gear teeth. Refer to **Figure 6.56**.

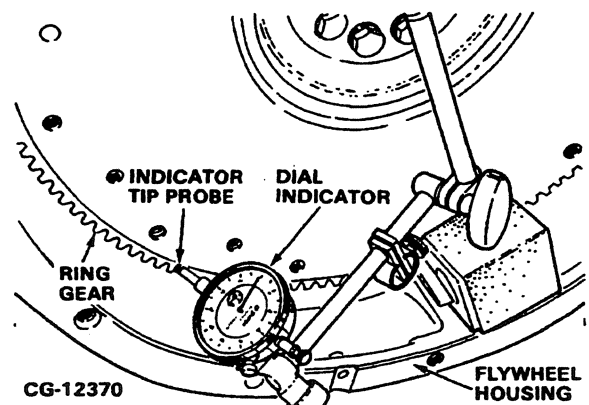
b. Push flywheel forward prior to turning the flywheel, so crankshaft "end play" will not be indicated as flywheel run-out.

c. Set the dial indicator to zero. Turn the flywheel one complete revolution while observing the total indicator run-out (T.I.R.).

d. If flywheel face T.I.R. exceeds specifications, remove flywheel and check for burrs between the flywheel and face of the crankshaft mounting flange. Remove burrs as required.



**Figure 6.56. Checking Flywheel Run-Out**



**Figure 6.56. Checking Ring Gear Run-Out**

## SERVICE MANUAL

### CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

#### FLYWHEEL (Reconditioning)

##### ■ Installation (Rear Cover Assembly and Flywheel) – Continued

- e. If no burrs exist, recheck the crankshaft flange run-out, using a dial indicator.
- If run-out is excessive, replace the crankshaft.
- If the crankshaft flange run-out is within specifications, resurface (manual transmission only) or replace the flywheel as required.
- f. If ring gear T.I.R. exceeds specifications, check ring gear installation. Reheat the gear evenly until it expands enough to be properly seated on the flywheel shoulder.
- g. Recheck run-out; if not within specifications, replace the flywheel and ring gear assembly.

**NOTE:** Flywheel housing pilot bore concentricity and flywheel housing face run-out should be checked to ensure proper engine to transmission alignment.

8. Check flywheel housing bore concentricity as follows:

- a. Attach a magnetic base dial indicator to the flywheel and place the indicator tip against the flywheel housing pilot bore. Refer to Figure 6.57.
- b. "Zero" the dial indicator.
- c. Rotate the crankshaft slowly and record the total indicator variation. Refer to "SPECIFICATIONS" for housing bore concentricity tolerance.

9. Check flywheel housing face run-out as follows:

- a. Attach a dial indicator to the flywheel and place the indicator tip against the flywheel housing face. Refer to Figure 6.58.
- b. Measure at four points, 90° apart, for total face variation.

#### IMPORTANT

**"ZERO" THE CRANKSHAFT END PLAY BY PUSHING THE CRANKSHAFT IN THE SAME DIRECTION FOR ALL MEASUREMENTS.**

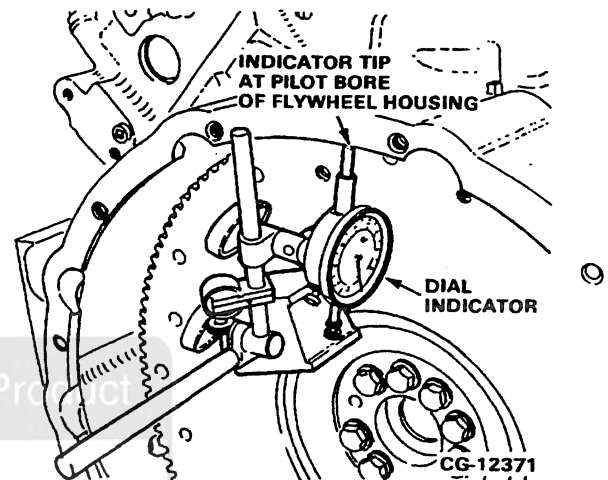


Figure 6.57. Check Flywheel Housing Pilot Bore Concentricity

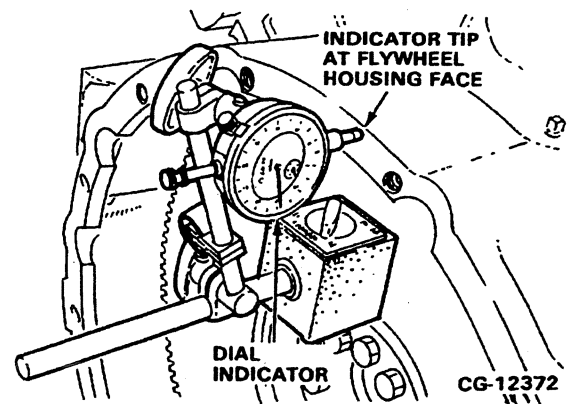


Figure 6.58. Check Flywheel Housing Face Run-Out

10. Engines with automatic transmissions must have the reinforcement ring and flex plate installed after the flywheel passes inspection.



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## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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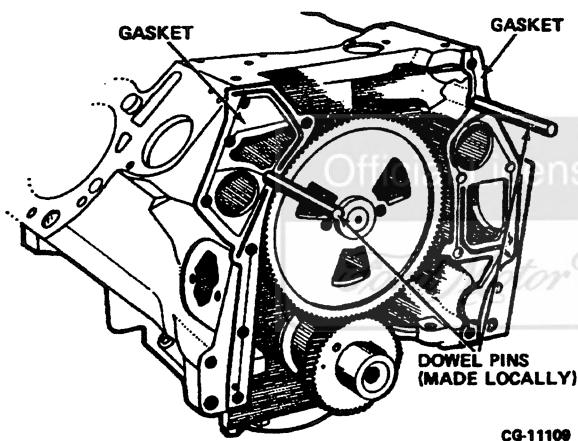
### FRONT COVER, DAMPER AND OIL PAN

#### ■ Installation

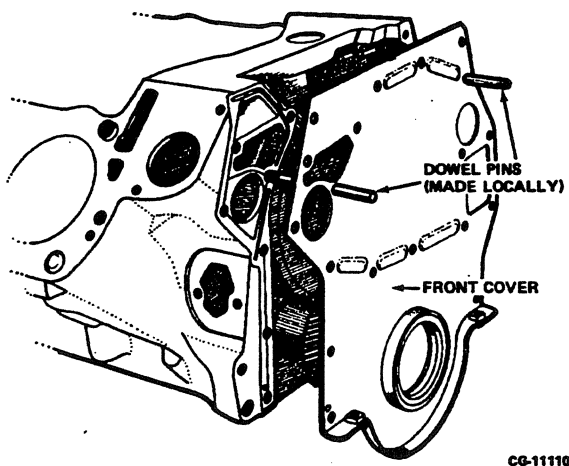
#### ● FRONT COVER

1. Position two new front cover gaskets on the crankcase and install the engine front cover with new front oil seal, **Figure 6.59**.

NOTE: Dowel pins are made locally to provide proper alignment. Refer to **Figure 6.60**.



**Figure 6.59. Dowel Pins and Gaskets Installed**



**Figure 6.60. Installing Front Cover**

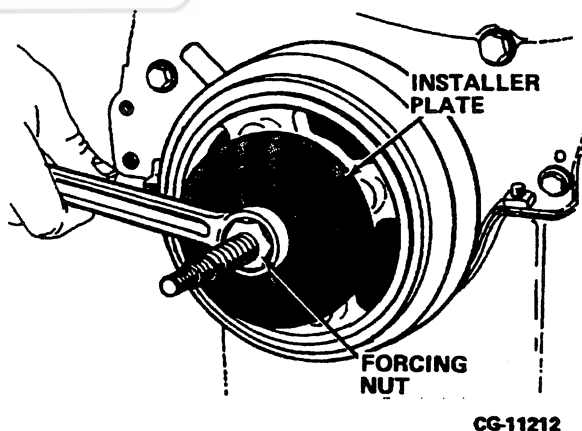
#### ● DAMPER

2. Install the crankshaft vibration damper using ZTSE-1900-69, damper, crankshaft and camshaft gear installer, **Figure 6.61**.

- Apply a small amount of R.T.V. sealant to the damper keyway area.
- Align the keyway in the damper with the key on the crankshaft.
- Assemble the installer plate with the threaded rod, thrust washer and forcing nut as shown in **Figure 6.61**.

NOTE: The spacer tube from ZTSE-1900-69 is not used to install the damper.

- Turn the forcing nut on ZTSE-1900-69 to install the damper.
- Remove tool and install damper bolt and washer. Tighten to specified torque.



**Figure 6.61. Install Vibration Damper**

#### ● OIL PAN

3. Install oil pump assembly with pickup screen as shown in **Figure 6.62**. Tighten as required.

4. Wipe off all excess oil and foreign matter from sealing surface on crankcase, front plate, rear cover and oil pan prior to application of R.T.V.sealant.



# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

### FRONT COVER, DAMPER AND OIL PAN

#### ■ Installation Continued

#### ● OIL PAN – Continued

5. Prior to installing the oil pan onto the engine, place a 1/4" bead of R.T.V. sealant in 4 places as shown in Figure 6.62.

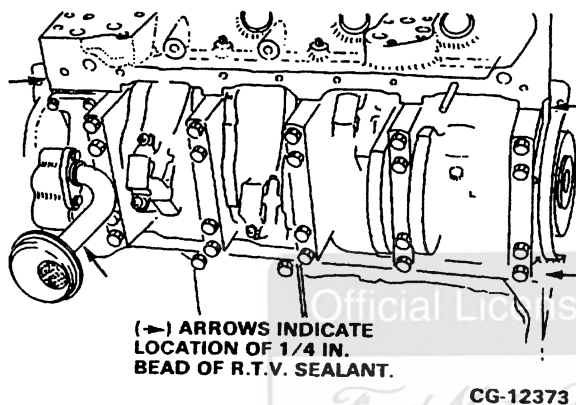


Figure 5.62. R.T.V. Application on Front and Rear Plate

6. Apply R.T.V. sealant (P/N 446 839 C1) to all pan surfaces as shown in Figure 6.63.

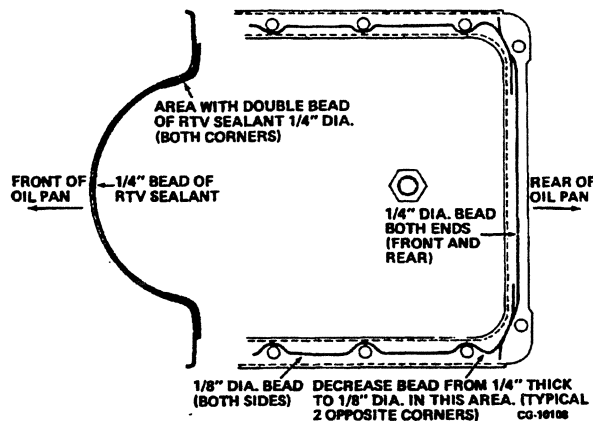


Figure 6.63. Application of R.T.V. on Oil Pan

NOTE: Corners have a double bead of R.T.V.

### CAUTION



Do not apply excessive amounts of R.T.V. which could end up in the pickup screen, restricting lube oil flow. Remove excess oil from gasket (R.T.V.) surface on oil pan and front and rear covers with a clean shop rag.

8. Install oil pan onto crankcase within 10 minutes of R.T.V. application. The use of guide pins is recommended as shown in Figure 6.64.

NOTE: Guide pins are made locally.

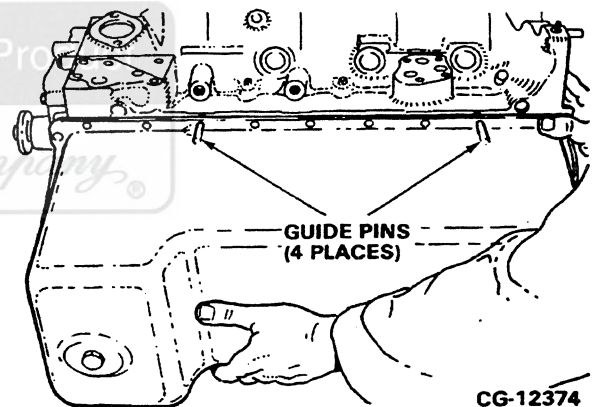


Figure 6.64. Install Oil Pan Using Guide Pins

9. Tighten the oil pan mounting bolts to the standard torque.

10. Install the oil pan drain plug using a new gasket and tighten to the specified "SPECIAL" torque.

11. Install the crankshaft pulley onto the vibration damper using the four mounting bolts and washers.

12. Reinstall all other components removed in preparation for servicing the crankshaft, bearings, flywheel and crankcase. See unit section for detailed reassembly procedures.

# SERVICE MANUAL

## CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE

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### FRONT COVER, DAMPER AND OIL PAN

#### ■ Installation Continued

New or overhauled engines which have been in storage should be primed at installation.

#### Prime Lubricating System:

1. When assembling the engine during overhaul, it is important to prelubricate the running parts with clean engine oil to assure initial lubrication when the engine is started.

**NOTE:** Refer to Section 8, "LUBRICATING OIL PUMP, OIL COOLER AND FILTER" for oil quality and viscosity recommendations, as well as oil fill capacity.

2. To further assure complete initial lubrication, the engine lubricating system should be pressure primed or charged with oil. Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure. After priming, check engine oil level and adjust (fill or drain) as needed before starting engine,

3. Operate the engine and check for leaks, correct as necessary. Shut engine down and recheck oil level. Add oil (if needed) or drain oil (if needed) to bring oil level to "full" mark on oil level gauge.

**NOTE:** Do not "overfill" past the full mark.



# SERVICE MANUAL

## WATER PUMP AND THERMOSTAT

---

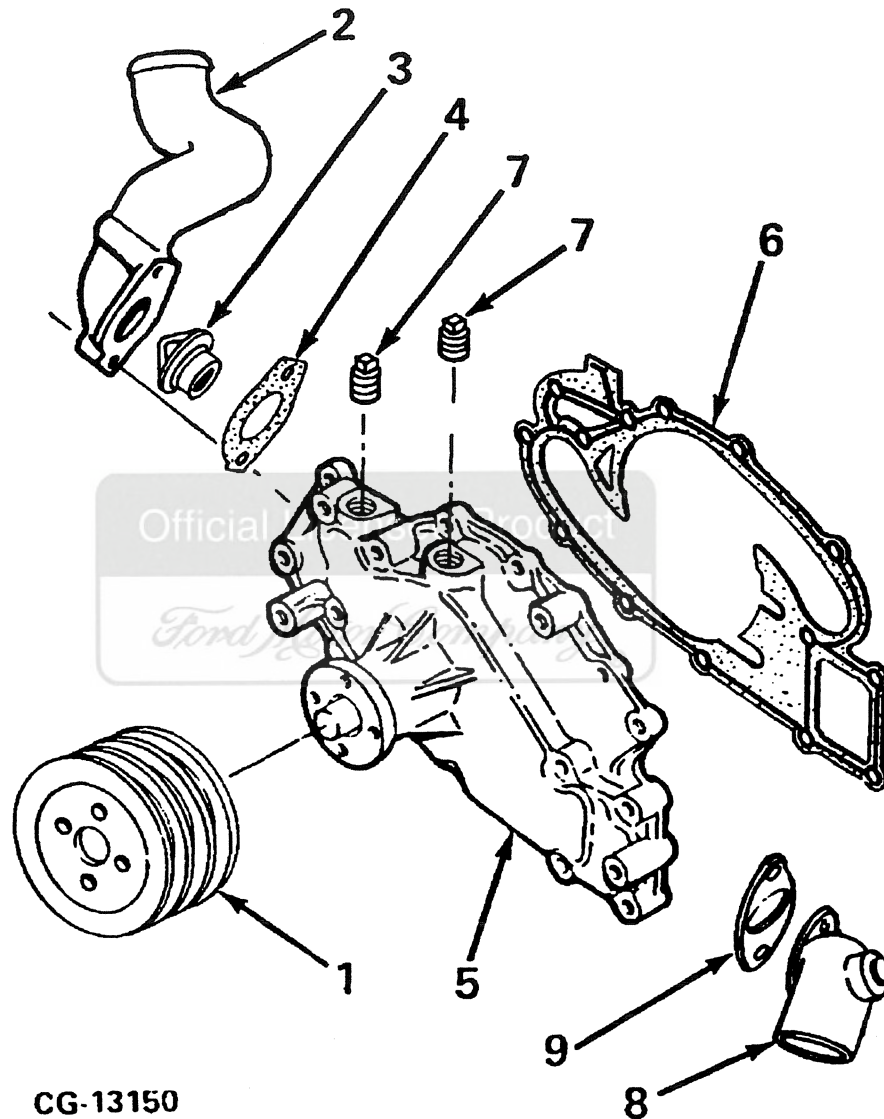
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# SERVICE MANUAL

## WATER PUMP AND THERMOSTAT

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Figure 7.1. Water Pump with Pulley

- |                                |                             |
|--------------------------------|-----------------------------|
| 1. Water Pump Pulley           | 6. Water Pump Gasket        |
| 2. Coolant Outlet Elbow        | 7. Pipe Plug 1/2-14 Sq. Hd. |
| 3. Thermostat (192°F)          | 8. Coolant Inlet            |
| 4. Coolant Outlet Elbow Gasket | 9. Coolant Inlet Gasket     |
| 5. Water Pump                  |                             |

SERVICE MANUAL  
WATER PUMP AND THERMOSTAT

SPECIFICATIONS

THERMOSTAT

Type ..... Poppet Valve, Pellet operated

Start to Open Temp. (Deg. F)	Full Open Temp. (Deg. F)
192° +0° -7°	212°

Operating Temperature Range .....

WATER PUMP

Type ..... Centrifugal, prelubricated  
Drive/Ratio ..... V-Belt/1.08:1  
Bearing No.Type ..... 1- Sealed, Unitized  
Capacity (gpm @ engine rpm) ..... 70 @ 3000

Official In-Service Product  
SPECIAL TORQUES

Water Pump Mounting Bolts (See Figure 7.2) ..... 14 lbf-ft. (19 N•m)  
Water Outlet Elbow Mounting Bolt ..... 20 lbf-ft. (27 N•m)

NOTE: Clean bolts thoroughly.  
APPLY AVIATION PERMATEX™  
#3 TO THESE BOLTS AND  
INSTALL WITHIN 5 MINUTES

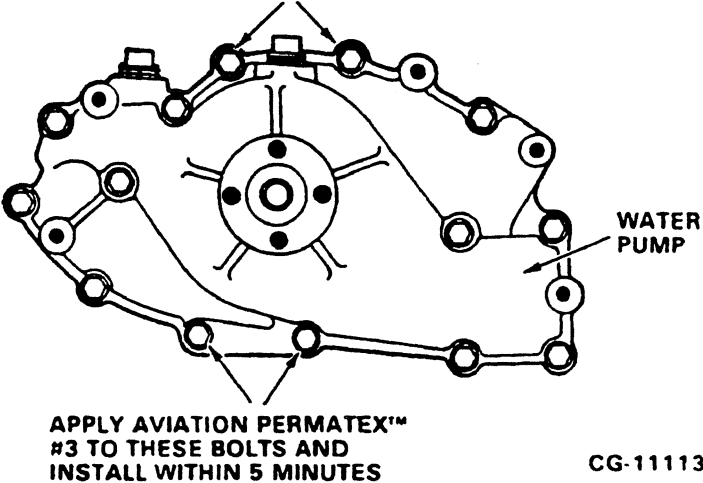


Figure 7.2. Water Pump Mounting Bolts

SPECIAL TOOLS

NO SPECIAL SERVICE TOOLS REQUIRED FOR THIS SECTION



# SERVICE MANUAL

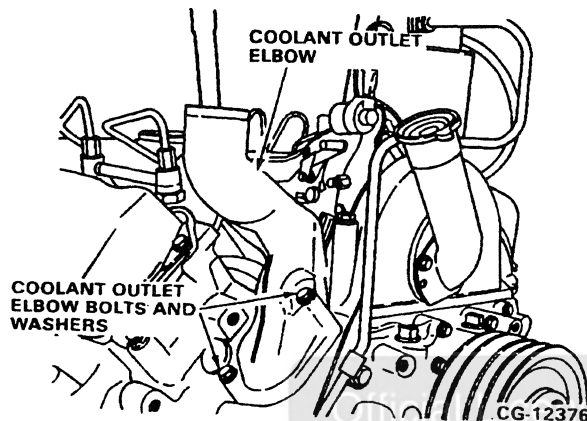
## WATER PUMP AND THERMOSTAT

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### WATER PUMP AND THERMOSTAT

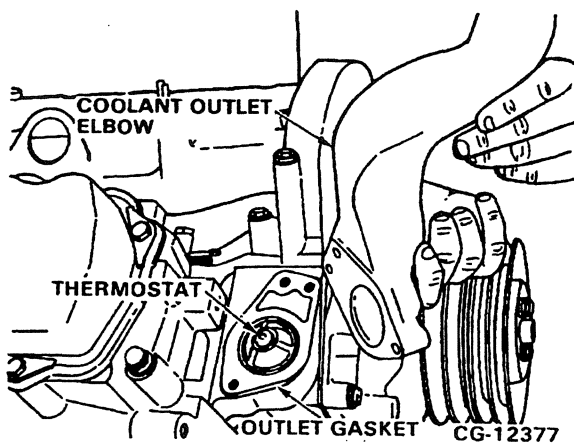
#### ■ Removal

1. Loosen and remove the two bolts and lock washers from the coolant outlet elbow, Figure 7.3.



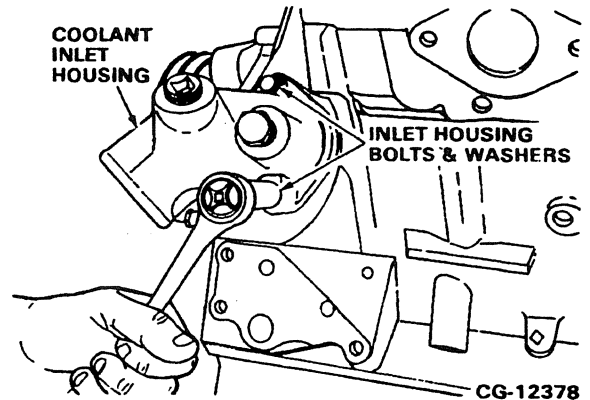
**Figure 7.3. Coolant Outlet Elbow Fastener  
[1988 MY and Earlier Shown]**

2. Remove the coolant outlet elbow, gasket and thermostat from the crankcase. Refer to Figure 7.4. Discard the gasket.



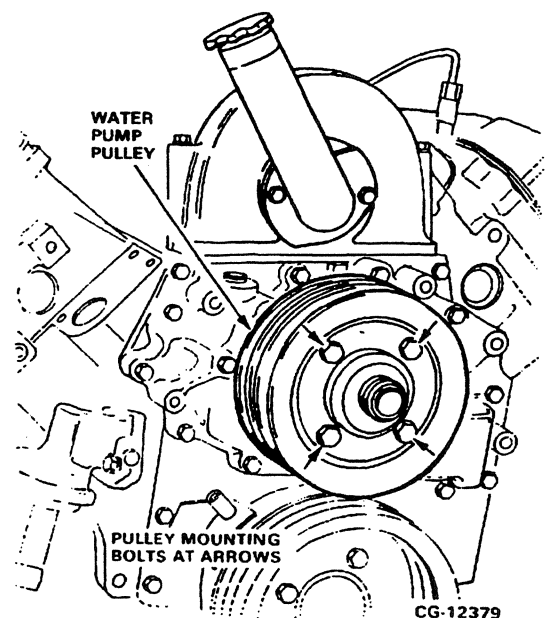
**Figure 7.4. Remove Outlet Elbow, Gasket  
and Thermostat**

3. Loosen and remove the two coolant inlet bolts and washers, as shown in Figure 7.5. Remove the inlet housing and gasket. Discard the gasket.



**Figure 7.5. Remove Coolant Inlet Housing**

4. While preventing pulley movement with a pry bar, loosen and remove the 4 pulley retaining bolts, then remove the pulley from the water pump hub. Refer to Figure 7.6.



**Figure 7.6. Water Pump Pulley Removal  
[1988 MY and Earlier Shown]**

## SERVICE MANUAL

### WATER PUMP AND THERMOSTAT

#### WATER PUMP AND THERMOSTAT

##### ■ Removal – Continued

5. Remove the 14 bolts and washers which secure the water pump to the front plate and crankcase. Refer to **Figure 7.7**. Note the location of the different bolt lengths. Remove the gasket and discard.

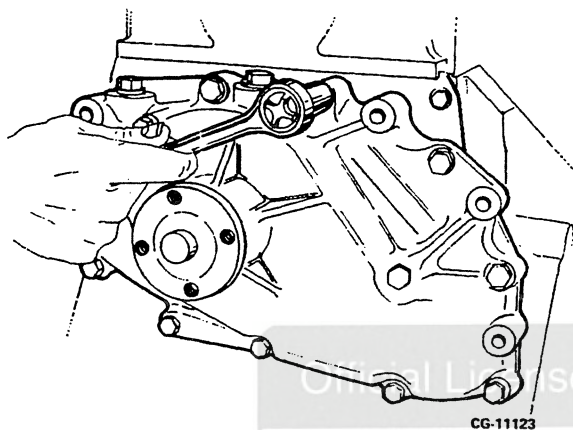


Figure 7.7. Water Pump Removal

##### ■ Inspection

##### ● Water Pump

1. The water pump should be visually inspected for damaged impeller, cracks and other faulty conditions. If any defects are noted, the water pump must be replaced as an assembly.

**NOTE:** Order water pump package and follow instructions included in the package.

##### ● Thermostat

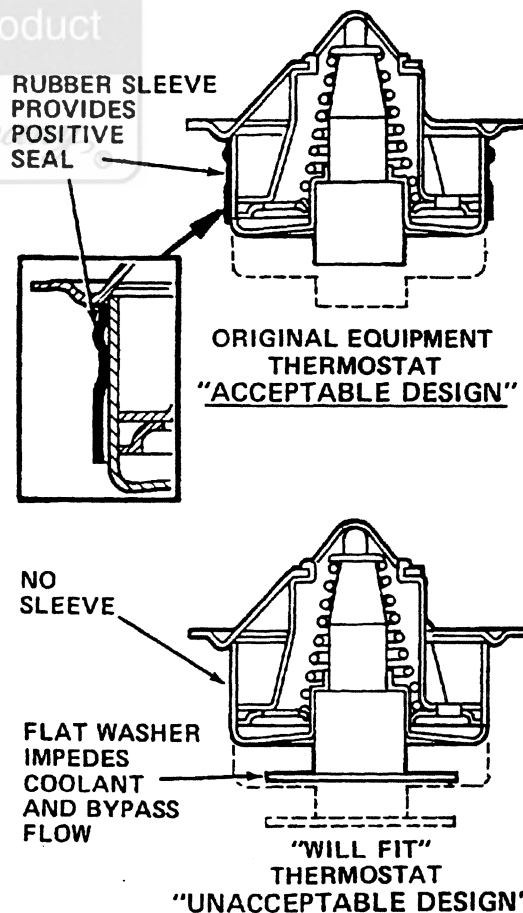
1. Inspect the thermostat for proper type (correct design) and temperature range.

#### IMPORTANT

WHEN SERVICING THE THERMOSTAT IT IS ESSENTIAL THAT THE THERMOSTAT OPENS FULLY UPON TEMPERATURE DEMAND TO AVOID AN OVER-HEATING CONDITION WHICH MAY CAUSE PREMATURE CYLINDER HEAD GASKET FAILURE.



**CAUTION:** After market "WILL FIT" thermostats may not fully open due to a flat washer secured to the end of the power pill which obstructs the by-pass and normal coolant flow. An additional disadvantage is their omission of the rubber sleeve which provides the positive seal. **ONLY GENUINE INTERNATIONAL® THERMOSTATS** assure the proper coolant flow and positive sealing characteristics required to provide long engine life. Refer to Figure 7.8.



CG-11118

Figure 7.8. Thermostat Design  
(Acceptable vs. Unacceptable)

# SERVICE MANUAL

## WATER PUMP AND THERMOSTAT

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Page 5

### WATER PUMP AND THERMOSTAT

■ Inspection – Continued

● Thermostat – Continued

2. Check thermostat operation as follows:  
(Refer to Figure 7.9).

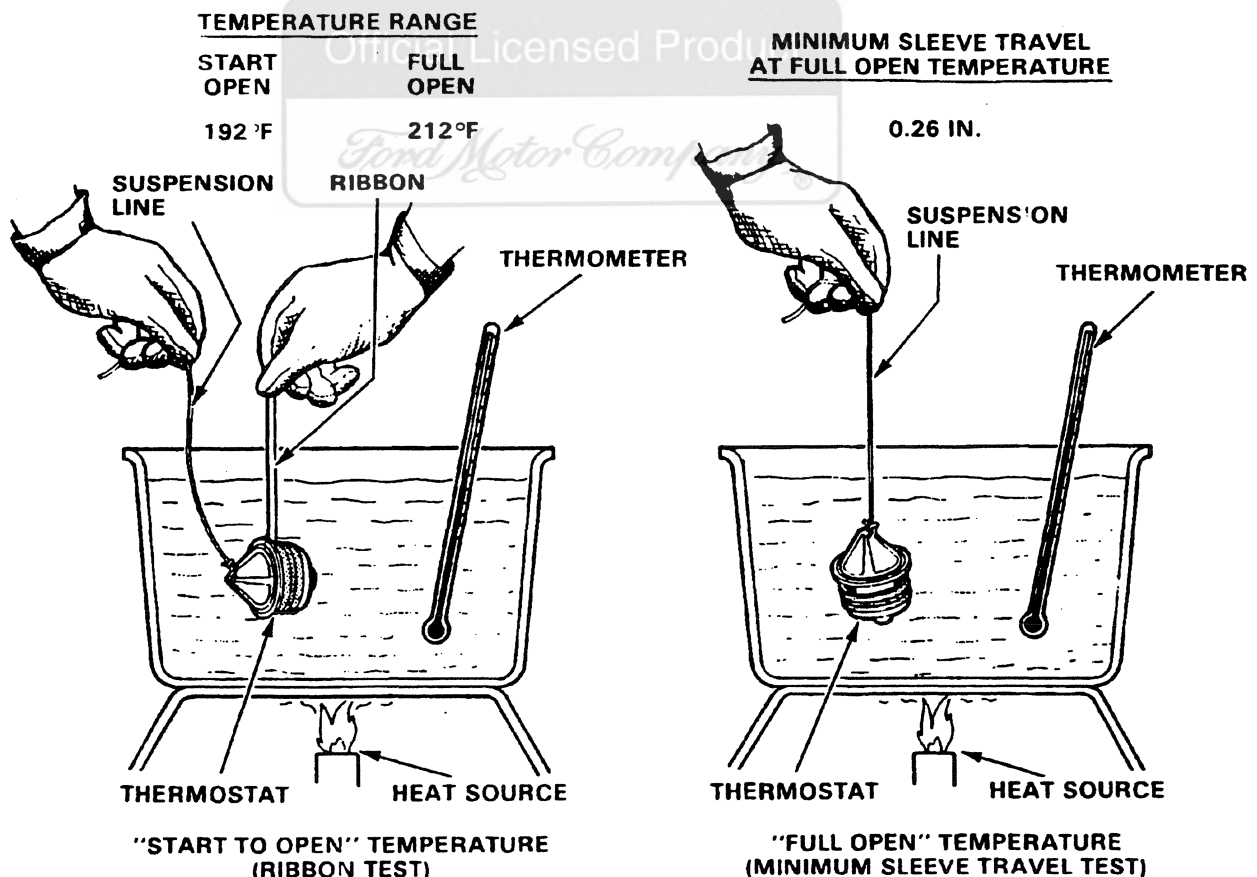


#### CAUTION !

Exercise caution and good judgement to avoid injury when dealing with hot water and objects during the thermostat operation check. Use heat resistant gloves and wear appropriate eye protection.

a. Manually open the thermostat enough to insert a nylon ribbon under the valve seat. Suspend the thermostat in the container so the thermostat does not touch the bottom of the container.

b. Heat the container filled with water to the "START-TO-OPEN" temperature of the thermostat ( $192^{\circ}\text{F} \pm 5^{\circ}$ ). Observe the thermometer and record the temperature as soon as the thermostat drops from the nylon ribbon. **THIS READING IS THE "START TO OPEN" TEMPERATURE.**



CG-11120

Figure 7.9. Thermostat Functional Test

## SERVICE MANUAL

### WATER PUMP AND THERMOSTAT

#### WATER PUMP AND THERMOSTAT

##### ■ Inspection – Continued

##### ● Thermostat – Continued

c. Continue to heat water to "FULL-OPEN" temperature of 212°F (100°C). Observe the thermometer and movement of thermostat sleeve. Observe thermostat sleeve movement when "FULL-OPEN" temperature is achieved. Minimum sleeve travel at "FULL-OPEN" temperature is .26 inches (6.35 mm). Refer to Figure 7.10.

d. Remove the thermostat from the water and while the sleeve is off its seat, inspect the seat area for pitting and foreign deposits.

e. Replace the thermostat if it does not operate as described or meet the visual inspection criteria.

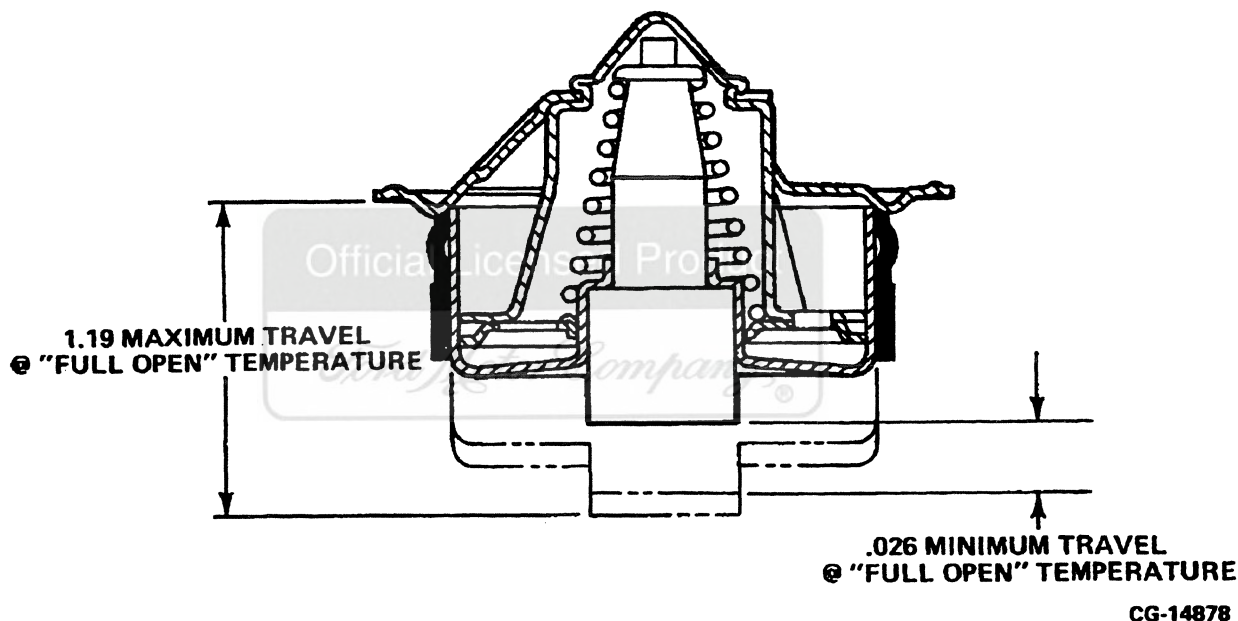


Figure 7.10. Visually Inspect Thermostat

##### ■ Installation

**NOTE:** Prior to installation, clean the gasket surfaces on both the water pump and front plate of the engine. Coat both the water pump and front plate gasket surfaces with a thin film of Aviation Permatex™ No. 3 prior to installing gasket.

1. Place a new gasket on the water pump housing and install water pump as follows:

- Clean bolt threads thoroughly.
- Apply Aviation Permatex™ No. 3 to the designated bolts. Refer to Figure 7.11. Install the bolts within 5 minutes of the Permatex application.

- Install the water pump assembly using 1-1/2 in. long bolts and 2-3/4 in. long bolts as illustrated in Figure 7.11.

- Tighten bolts to specified torque.

**NOTE:** Refer to installation instructions 1 171 578 R1 included with the water pump service package.

2. Fasten the water pump pulley to the water pump hub using the 4 mounting bolts. Tighten to standard torque.

# SERVICE MANUAL

## WATER PUMP AND THERMOSTAT

Section 7  
Page 7

### WATER PUMP AND THERMOSTAT

#### ■ Installation – Continued

3. Install thermostat into the crankcase counterbore, positioned as shown in Figure 7.4.
4. Install a new coolant outlet gasket and fasten the coolant outlet elbow to the crankcase using the long and short mounting bolts, with washers. Tighten bolts to specified torque.
5. Using a new gasket, install the coolant inlet housing. Tighten the two mounting bolts with washers to standard torque.

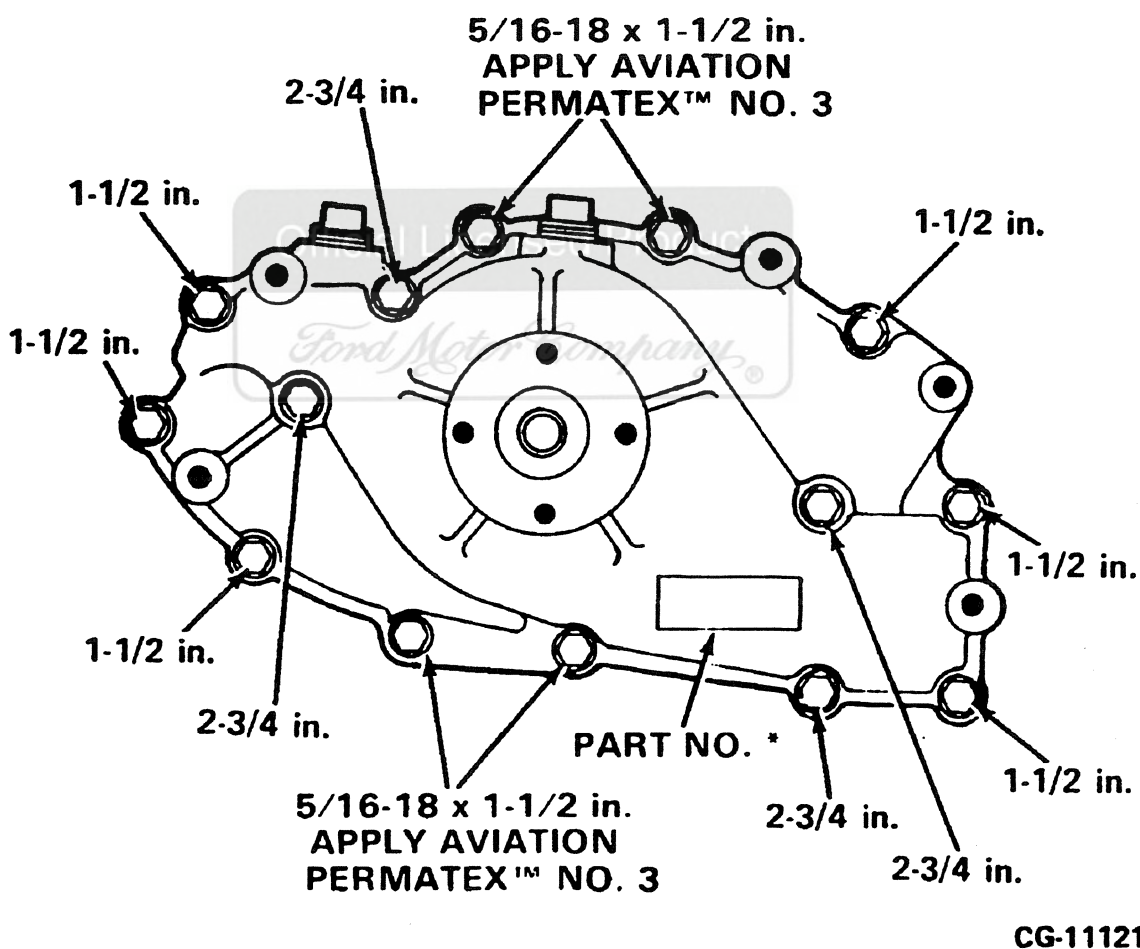


Figure 7.11. Water Pump Bolt Location For Installation

\*Casting Part No. Use for Identification Purposes Only.



# **SERVICE MANUAL**

## **LUBRICATING OIL PUMP, OIL FILTER AND COOLER**

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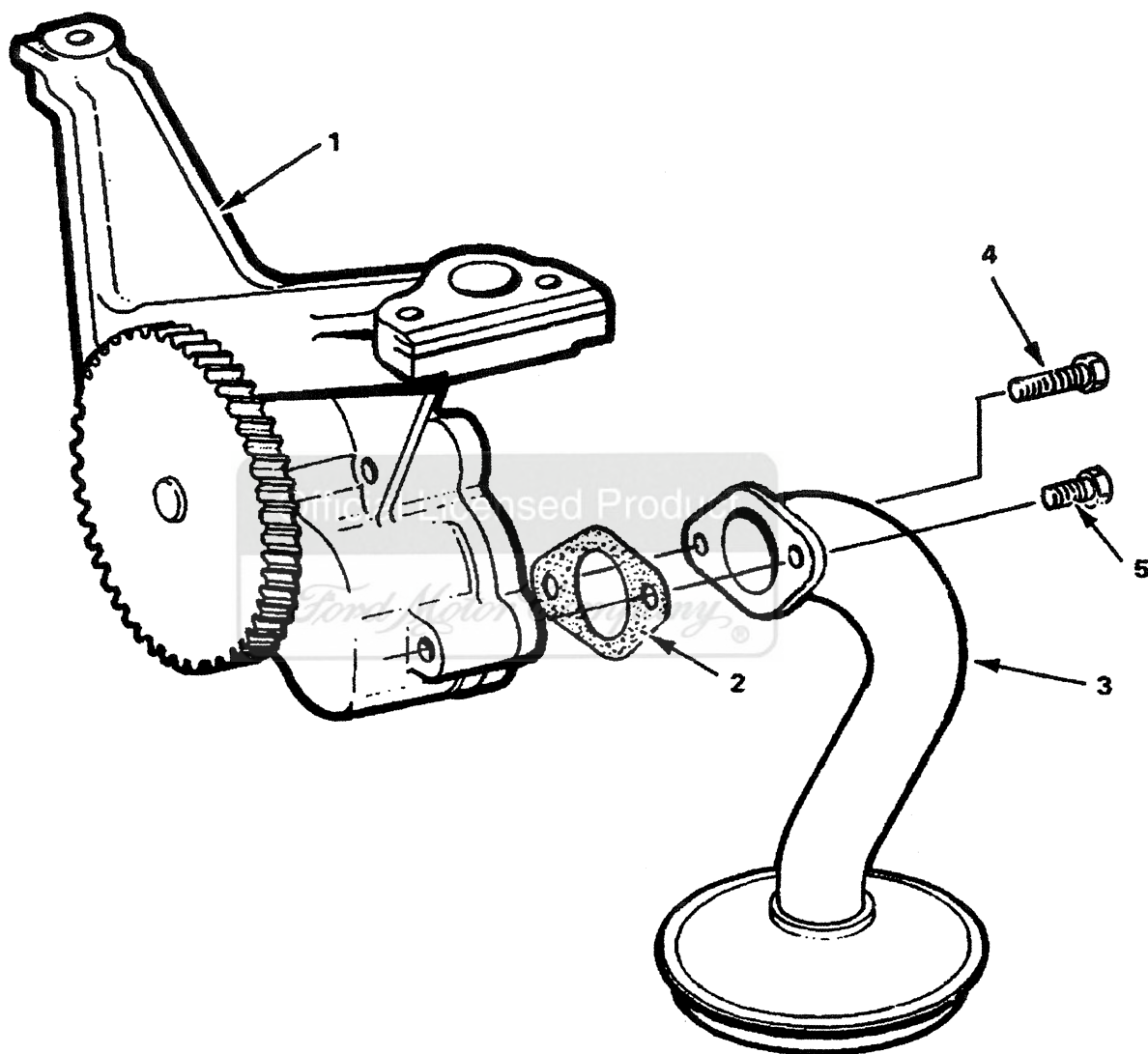
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# SERVICE MANUAL

## LUBRICATING OIL PUMP, OIL FILTER AND COOLER

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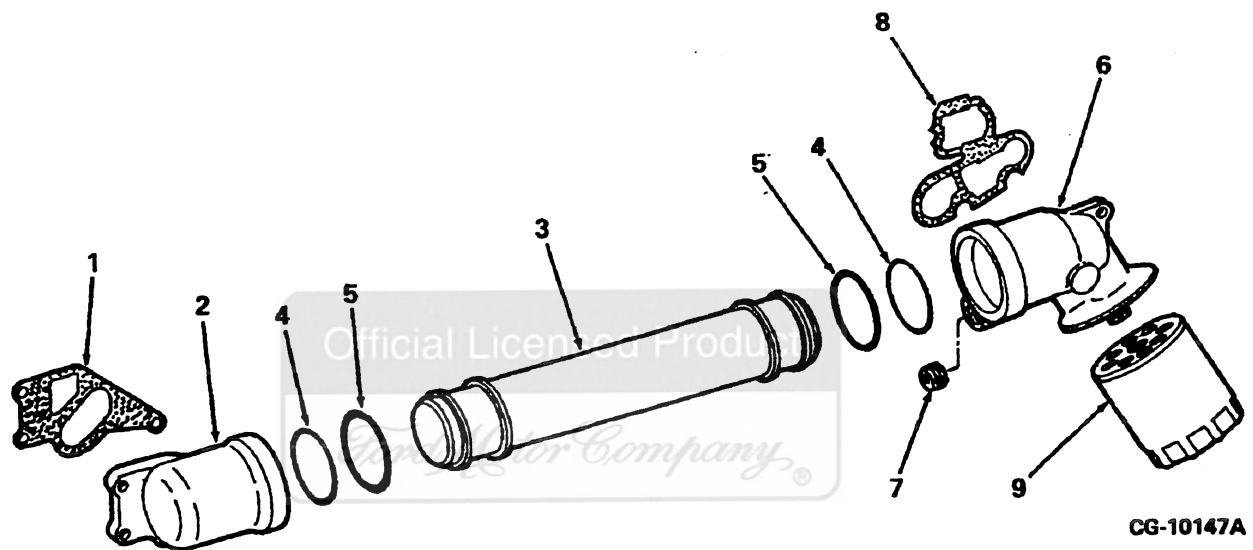
Figure 8.1. Oil Pump and Pickup Assembly

- |                           |  |
|---------------------------|--|
| 1. Oil Pump with Gear     | 4. 5/16 in. NC x 2 in. Hex Head Bolt<br>w/Hardened Washer  |
| 2. Oil Pickup Tube Gasket | 5. 5/16 in. NC 1-1/2 in Hex Head Bolt<br>w/Hardened Washer |
| 3. Oil Pickup Tube        |  |

## SERVICE MANUAL

### LUBRICATING OIL PUMP, OIL FILTER AND COOLER

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CG-10147A

Figure 8.2. Oil Cooler Assembly

- |                            |                           |
|----------------------------|---------------------------|
| 1. Front Header Gasket     | 6. Filter Header Assembly |
| 2. Front Oil Cooler Header | 7. 1/2" Hex Head Plug(+)  |
| 3. Oil Cooler              | 8. Filter Header Gasket   |
| 4. O-Ring (Thin)           | 9. Lube Oil Filter        |
| 5. O-Ring (Thick)          |                           |

(+) Location for by-pass filter oil supply

# SERVICE MANUAL

## LUBRICATING OIL PUMP, OIL FILTER AND COOLER

Section 8  
Page 3

### SPECIFICATIONS

#### LUBRICATING OIL PUMP:

Type ..... Gear Pump, Gear Driven  
Location ..... Inside Oil Pan  
Capacity (gpm @ rpm) ..... 18.2 @ 3000  
Gear Drive Ratio ..... 1.06:1  
Gear Backlash ..... 0.0056–0.010" (0.142–0.254 mm)  
End Play ..... 0.0025"–0.0065" (0.0635–0.1651 mm)  
Engine Lube Oil Pressure  
(Engine at Operating Temperature) ..... 10 psi (69 kPa) min. @ 700 RPM  
40–70 psi (276–482 kPa) @ Governor Speed RPM (No Load)

#### ENGINE OIL CAPACITY:

(Without Filter) ..... 15 Qts. (14.2 L)  
(With Filter) ..... 16 Qts. (15.1 L)

#### OIL COOLER:

Type ..... Full-Flow, Cylindrical Tube and Fin Bundle  
Location ..... Left Side of Engine

#### OIL FILTER:

Type ..... Spin-On, Full Flow – Disposable  
Location ..... Left Side, Oil Cooler Mounted  
Filter By-Pass Location ..... In Oil Filter Header

#### BY-PASS VALVE SPRING: (NOT SERVICED)

Free Length ..... 1.767 in. (44.88 mm)  
Test Length ..... 0.820 in. (20.83 mm)  
Test Load ..... 3.93 lbs. (17.5N)

#### PRESSURE REGULATING VALVE SPRING: (NOT SERVICED)

Free Length ..... 1.547" (39.29 mm)  
Test Length ..... 0.915" (23.24 mm)  
Test Load ..... 5.82 ±.29 lbs (25.89 ±1.29 mm)

#### PRESSURE REGULATING VALVE: (NOT SERVICED)

Location ..... Oil Filter Header (After the oil cooler and before the oil filter)  
Setting ..... 50 psi (344.7 kPa)

### SPECIAL TORQUES

Oil Pan Drain Plug ..... 28 lbf-ft. (37 N·m)

### SPECIAL SERVICE TOOLS

NO SPECIAL SERVICE TOOLS REQUIRED

## SERVICE MANUAL

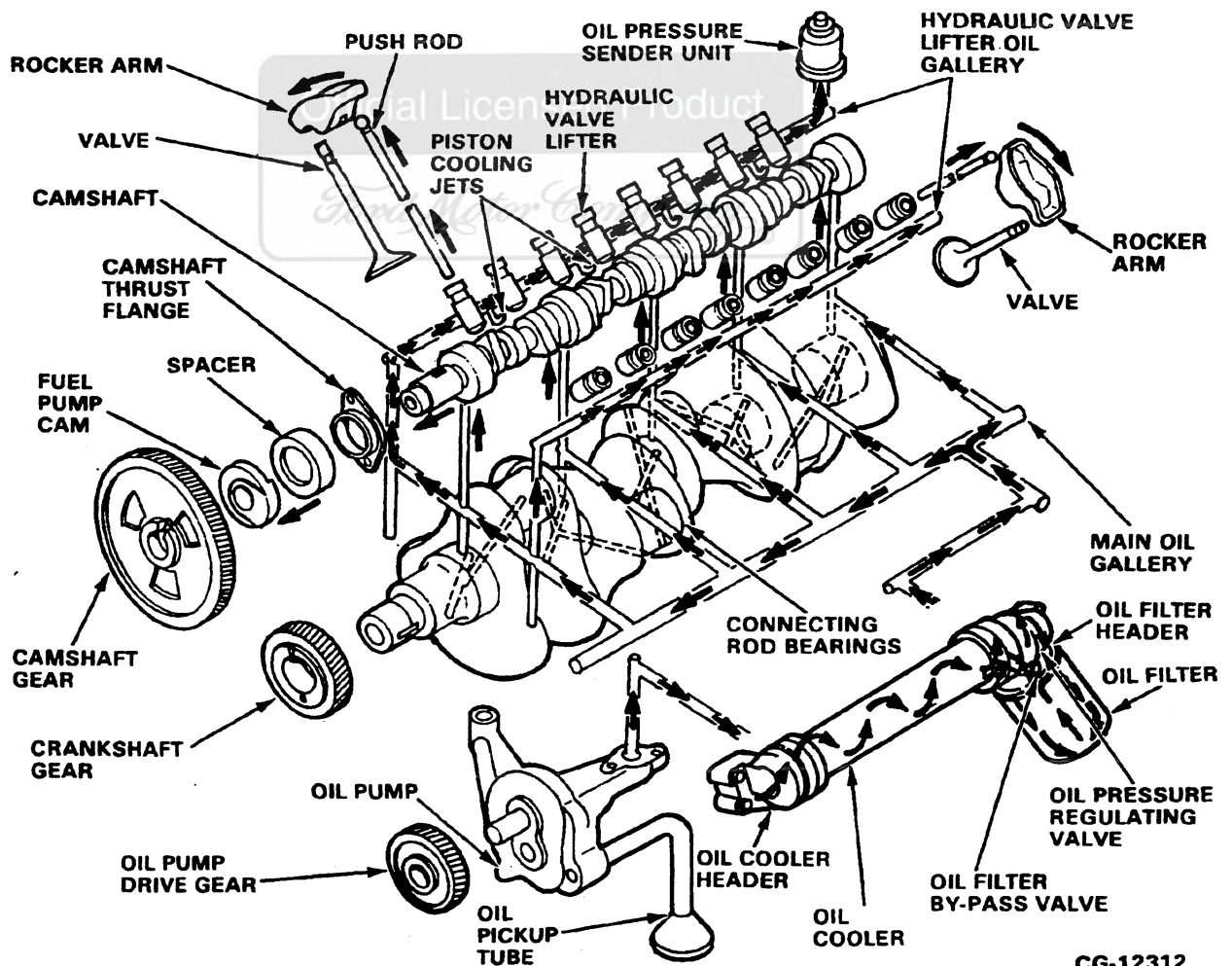
### LUBRICATING OIL PUMP, OIL FILTER AND COOLER

#### GENERAL OPERATION

■ Lubricating System (Refer to **Figure 8.3**)

Lube oil is drawn out of the sump through the pick-up screen and oil pick-up to the oil pump. From the oil pump, oil is passed via drilled passageways in the crankcase to the oil cooler. Oil flows around the outside of the heat exchanger, tubes. (Coolant flows through the tubes.) The oil passes around the tubes rearward to the oil filter header. At the oil filter header the oil meets the pressure regulating valve, which regulates the oil flow and pressure to the oil filter and the engine oil galleries. Five cross pas-

sages distribute oil to vertical passages which feed the crankshaft main bearings, camshaft bearings and two valve lifter galleries. The piston cooling jets are fed from the same passage as the valve lifters. The connecting rod bearings are fed from the main bearings via drilled passages in the crankshaft. The timing gears are lubricated by oil exiting from the front camshaft bearing. Oil passes through the hydraulic valve lifter galleries and up the hollow push rods to lubricate the rocker arm assemblies and valve stems.



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Figure 8.3. Lubrication Schematic



# SERVICE MANUAL

## LUBRICATING OIL PUMP, OIL FILTER AND COOLER

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### GENERAL OPERATION

#### ■ Lubricating System – Continued

##### ● By-Pass Valve (Refer to Figure 8.4)

The by-pass valve is located in the oil filter-cooler header. The by-pass valve controls oil flow through the filter. Depending upon immediate conditions, the oil can travel in one of two directions or, in some cases, divide and travel in both directions.

During normal operation, the flow of oil continues on through the filter element on its way to the crankcase main oil gallery. However, if the filter is not changed every 6000 miles (9656 km), 200 hours or 2 months, whichever occurs first, excessive filter contamination and pressure drop will result. When such contamination occurs, the pressure differential type of by-pass valve will open allowing the oil to by-pass the filters and flow directly into the crankcase main oil gallery where it is distributed to all parts of the engine.

##### ● Oil Pressure Regulator Valve: (Refer to Figure 8.5)

The unique design of the oil pressure regulator valve extends the life of the oil filter in that it controls the volume and pressure of the filtered oil supplied to the engine. The volume of oil supplied by the pump is in excess of what is needed to lubricate the engine. This valve divides that flow. The volume needed to lubricate the engine is directed to the filters and excess is dumped to return. When all points of lubrication within the engine are satisfied, restriction to flow causes pressure to build in the filtered oil gallery and on the face of the valve. As this force moves the valve toward the regulator spring the port in the unfiltered oil gallery is uncovered and excess oil is dumped to return. Due to volume changes caused by changes in engine RPM the valve will dump more or less oil to the return keeping filtered oil pressure and volume within the specified range. Thus, the only oil filtered is that which is needed to lubricate the engine.

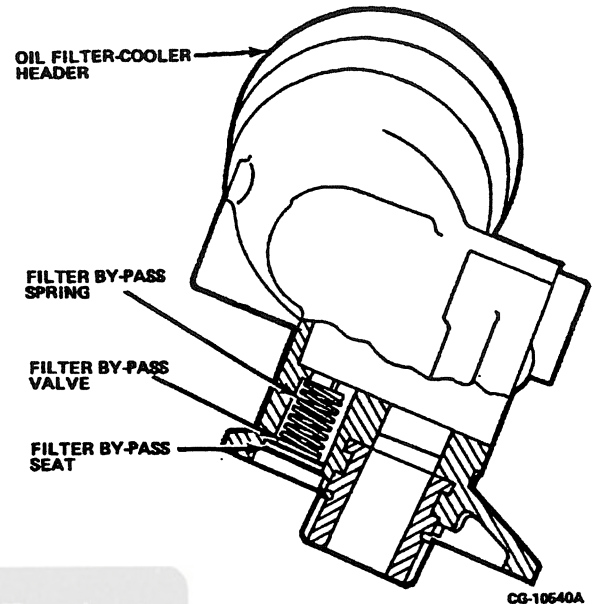


Figure 8.4. Oil Filter By-Pass Valve in Header

**NOTE:** The oil pressure regulator and by-pass valves are not serviced separately. If valves are suspected of being faulty, the oil filter-cooler header must be replaced.

##### ● Oil Pump:

The oil pump is a positive displacement gear driven unit located in the front of the front bearing cap and driven by the crankshaft gear.

##### ● Oil Cooler:

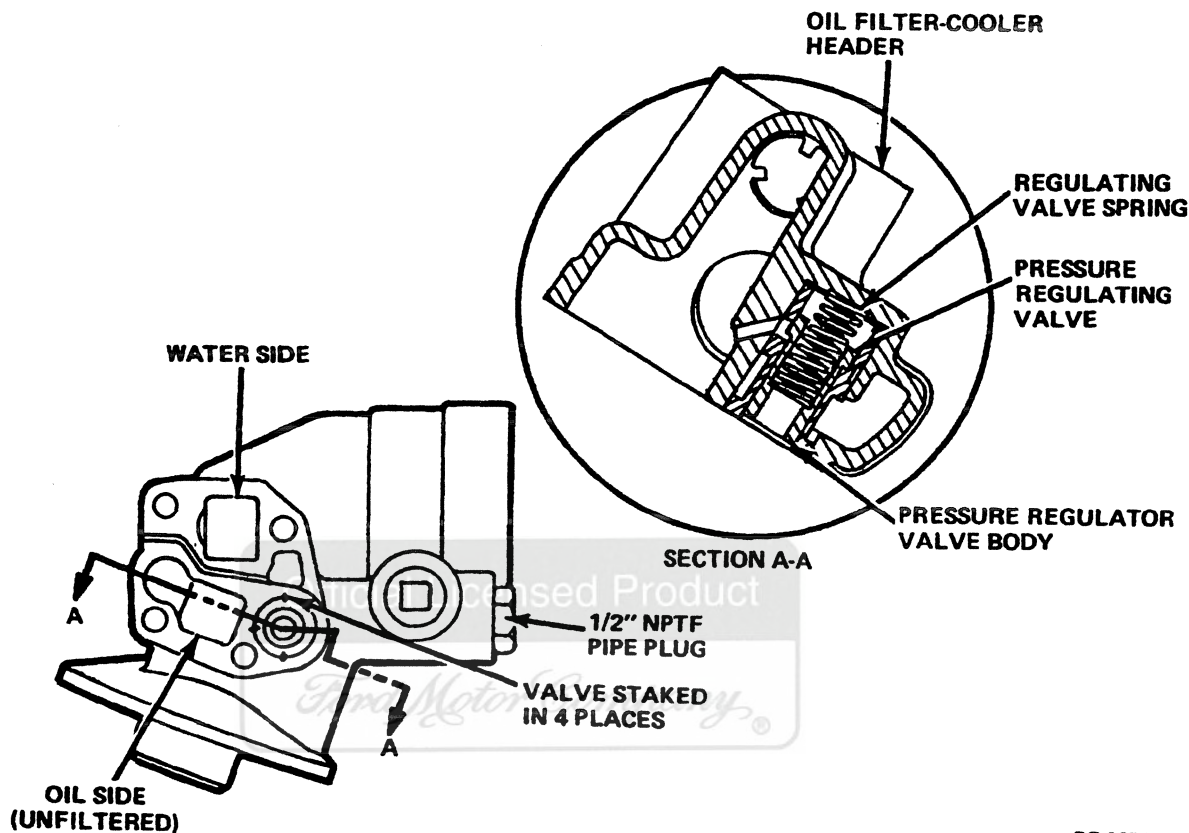
The oil cooler is mounted on the left side of the engine. All of the engine oil is circulated from the oil pump through the cooler and into the oil filter. Coolant flows from the radiator through the numerous tubes in the cooler. Headers are die cast aluminum. The oil filter-cooler header houses the filter by-pass pressure regulator valves.

## SERVICE MANUAL

### LUBRICATING OIL PUMP, OIL FILTER AND COOLER

#### GENERAL OPERATION

##### ■ Lubricating System – Continued



CG-10541

Figure 8.5. Oil Pressure Regulating OIL PUMP (Removal and Reassembly)

#### OIL PUMP (Removal and Reassembly)

##### ■ Removal

1. Remove the oil drain plug and gasket to drain engine oil from the system.
2. Loosen and remove the oil pan mounting bolts and washers which secure the oil pan.
3. Insert two pry bars through the crankcase dowel-holes on the left side of the crankcase pan rail. Pry the oil pan off. This prevents pan rail damage and distortion. Refer to Figure 8.6.

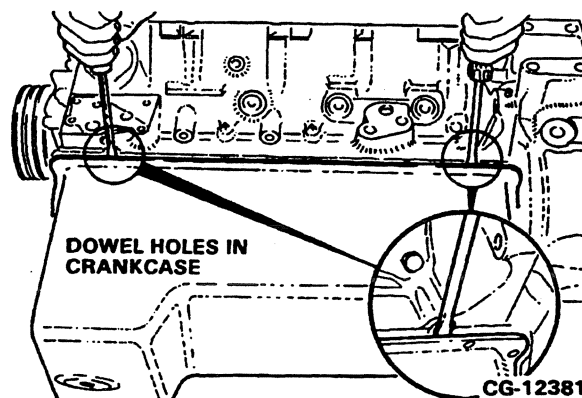


Figure 8.6. Oil Pan Removal

**NOTE:** The oil pan is GASKETLESS. R.T.V. sealant (Part No. 446 839 C1) is used to seal the oil pan to the crankcase.

4. Loosen and remove the two oil pickup tube retaining bolts. Note the location of the long and short bolt for reassembly. Refer to Figure 8.7.

# SERVICE MANUAL

## LUBRICATING OIL PUMP, OIL FILTER AND COOLER

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### OIL PUMP (Removal and Reassembly) - Continued

#### ■ Removal - Continued

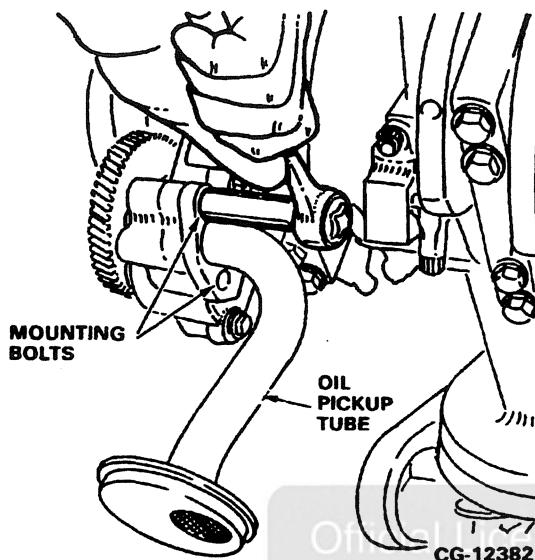


Figure 8.7. Remove Oil Pickup Tube

5. Prior to oil pump removal, check and record oil pump drive gear to crankshaft gear backlash as follows: (Refer to **Figure 8.8.**)

- Mount a magnetic base dial indicator on the front of the crankcase with the tip of the dial indicator tip on a gear tooth of the oil pump drive gear.
- "Zero" the dial indicator.
- Move the oil pump gear, by hand, to the right and left.
- Record each reading (right and left). If backlash exceeds the specifications, replace the oil pump assembly.

6. Check oil pump drive gear end play, prior to oil pump removal as follows:

- Mount a magnetic base dial indicator on the front of the crankcase with the tip of the dial indicator on the oil pump gear face.

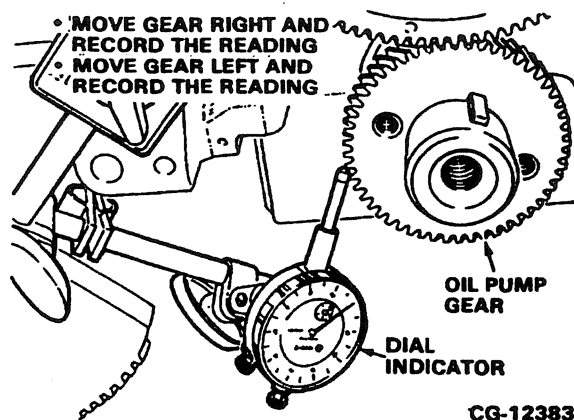


Figure 8.8. Check Oil Pump Drive Gear to Crankshaft Gear Backlash

b. Gently push the oil pump gear towards the rear of the engine and "ZERO" the indicator.

c. Insert a pry bar behind the gear and push the gear forward. Read indicator.

d. If end play specifications are exceeded, replace the oil pump assembly.

7. Loosen and remove the three oil pump mounting bolts and washers (**Figure 8.9**) then remove the oil pump from the crankcase.

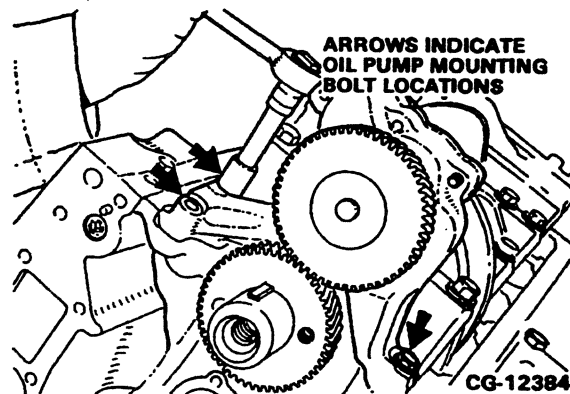


Figure 8.9. Remove Oil Pump Assembly

## SERVICE MANUAL

### LUBRICATING OIL PUMP, OIL FILTER AND COOLER

#### OIL PUMP (Removal and Reassembly) – Continued

##### ■ Cleaning

1. Clean R.T.V. sealant from the oil pan and crankcase using a scraper or wire brush. Scrape all gasket material from mating pin.
2. Clean all parts thoroughly in a suitable solvent, then dry with compressed air.

##### ■ Inspection

1. Visually inspect oil pump gear for chipped or broken teeth. Replace entire oil pump assembly if gear is damaged.
2. If backlash is not within specifications, replace the oil pump assembly.
3. Visually inspect the brazed areas of the oil pickup tube, using standard dye penetrant checking methods, to detect cracks. Replace the oil pickup tube if cracks are detected.

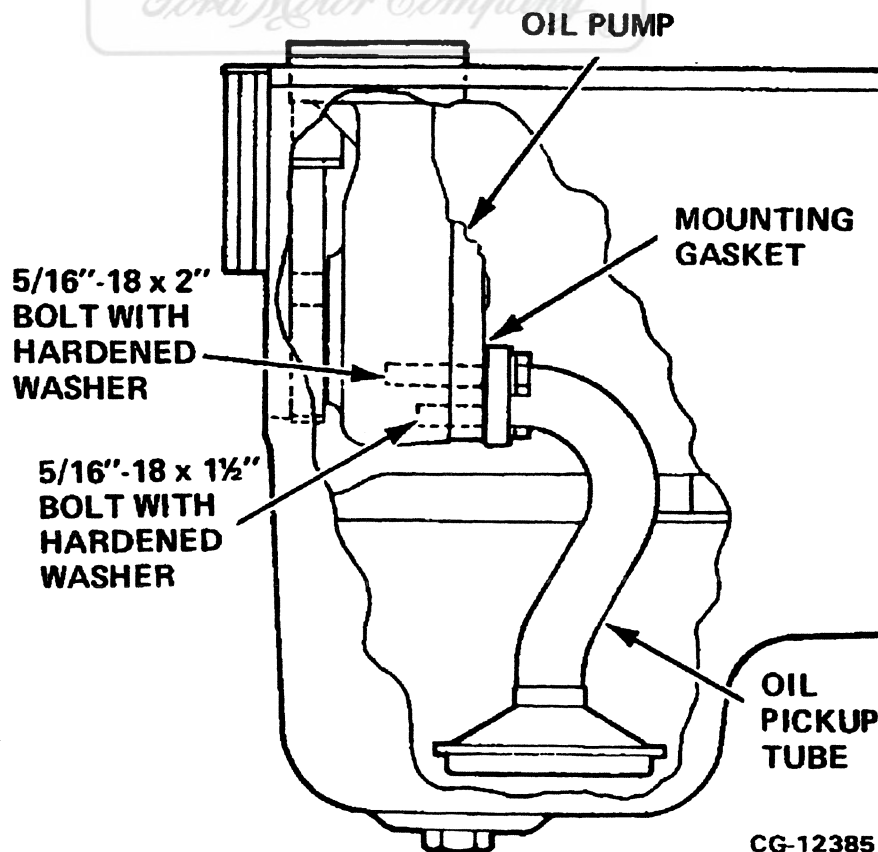
##### ■ Installation

1. Install the oil pump in front of the front bearing cap. Use the three hex-head 5/16"-18 x 1-1/2" bolts and 5/16" hardened washers.
2. Install oil pickup tube (**Figure 8.10**) to oil-pump using new mounting gasket as follows;

Install the 5/16"-18 x 1-1/2", bolt with hardened washer and the 5/16"-18 x 2" bolt with hardened washer as shown in **Figure 8.10**.

**NOTE:** Be sure the 2 in. long bolt is located on top and the 1-1/2 in. long bolt is below as shown in **Figure 8.10**.

3. Install oil pan. Refer to Section 6, "Crankshaft, Main Bearings, Flywheel and Crankcase" for oil pan installation instructions.



CG-12385

Figure 8.10. Oil Pickup Tube Installation

# SERVICE MANUAL

## LUBRICATING OIL PUMP, OIL FILTER AND COOLER

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### OIL COOLER (Removal and Reassembly)

#### ■ Removal

1. Using a filter wrench, loosen and remove the oil filter, then discard.
2. Loosen and remove the three 12 point mounting bolts and washers at the front header as well as the four hex head bolts and washers at the rear header.
3. Remove the oil cooler assembly and gaskets. Discard the gaskets.

**IMPORTANT**  
**PRIOR TO DISASSEMBLY, PERFORM**  
**"OIL COOLER LEAKAGE TEST".**

#### ■ Leakage Test

Inspect the oil cooler assembly for leaks using an "Air Pressure" test as follows:

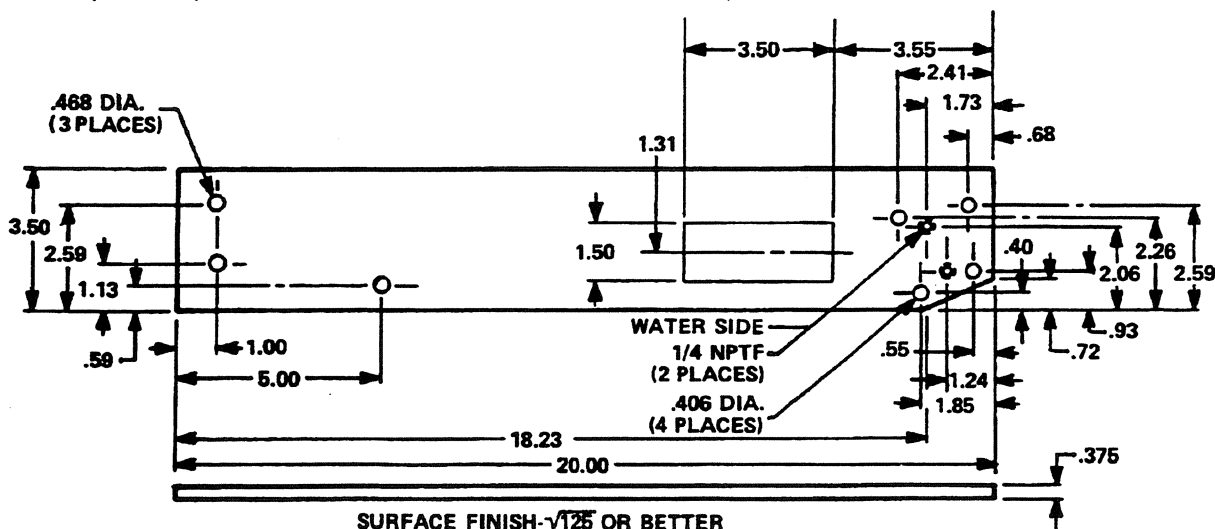
1. Construct a plate as shown in **Figure 8.11**.
2. Fasten the plate, using new oil cooler gaskets, to the cooler (**Figure 8.12**).
3. Install oil filter, O-rings and all pipe plugs in headers prior to pressure checks.

#### 4. OIL SIDE PRESSURE CHECK:

- a. Leave water side 1/4NPTF hole in plate open.
- b. Install an air pressure hose to the oil side 1/4NPT hole in plate.
- c. Immerse the assembly in a container of clean "tap" water.
- d. Apply 40-60 psi air pressure while immersed.
- e. Inspect header castings, O-ring seals and 1/4NPTF water side opening for moving or growing bubbles. Replace components as required.

#### 5. WATER SIDE PRESSURE CHECK:

- a. Leave oil side 1/4NPTF hole in plate open.
- b. Install an air pressure hose to the water side 1/4NPTF hole in plate.
- c. Immerse the assembly in a container of "tap" water.
- d. Apply 40-60 psi are pressure while immersed.
- e. Inspect header castings for moving or growing bubbles. Replace components as required.



CG-12426A

Figure 8.11. Pressure Plate Fabrication Detail



## SERVICE MANUAL

### LUBRICATING OIL PUMP, OIL FILTER AND COOLER

#### OIL COOLER (Removal and Reassembly)

##### ■ Leakage Test – Continued

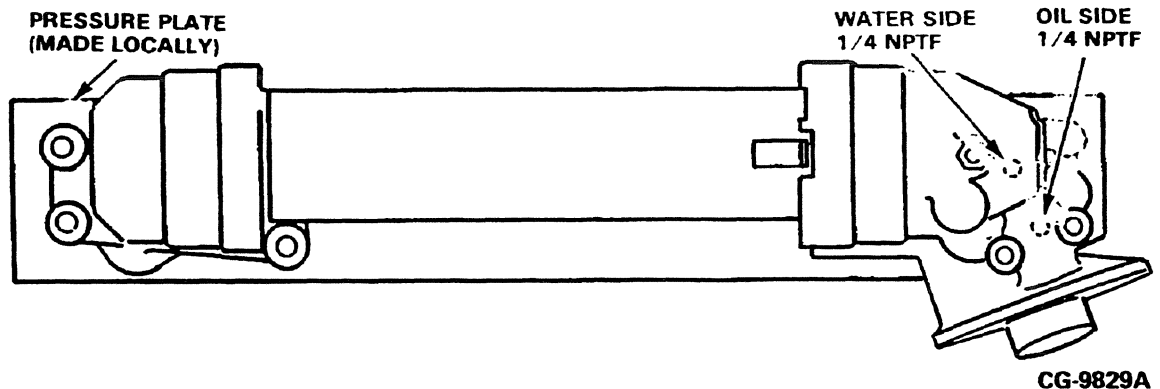



Figure 8.12. Pressure Plate Assembled to Cooler Assembly

##### ■ Disassembly

1. Gently rap front and rear oil filter headers to loosen O-rings. Twist headers separating from cooler bundle.



**CAUTION**  
In the event of bearing failure, the oil cooler bundle must be replaced, because failed bearing debris cannot be removed from the cooler bundle.

##### ■ Cleaning

1. Immerse oil cooler, front and filter headers in a suitable solvent. Flush and drain the cooler to remove residue.
2. Clean all gasket material from cooler assembly.
3. Dry all components thoroughly.

##### ■ Inspection and Repair

1. Visually inspect the oil cooler for blocked tubes and corrosion where tubes are assembled to the bundle. Replace the oil cooler tube bundle as required.

##### ■ Reassembly (Refer to Figure 8.13)

**IMPORTANT**  
USE NEW O-RING WHEN ASSEMBLING THE OIL COOLER ASSEMBLY.

**IMPORTANT**  
USE ONLY CLEAN ENGINE OIL FOR O-RING LUBRICATION.

**IMPORTANT**  
REPLACE O-RINGS WHICH MAY BE DAMAGED (NICKS OR CUTS, ETC.) DURING INSTALLATION

1. Using clean engine oil, lubricate the oil cooler bundle headers at the O-ring mating surfaces.
2. Install the large O-rings on the oil cooler bundle first, then install the small O-rings on the cooler bundle.
3. Carefully press assembly together assuring that the locating clip of the oil cooler rear header aligns in the slot of the cooler bundle and header is not cocked.

# SERVICE MANUAL

## LUBRICATING OIL PUMP, OIL FILTER AND COOLER

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### OIL COOLER (Removal and Reassembly)

#### ■ Reassembly – Continued

**NOTE:** The oil filter by-pass and oil pressure regulator, which are housed in the oil filter-cooler header, are not serviced separately.

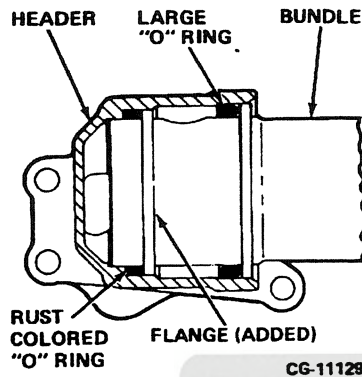


Figure 8.13. Oil Cooler Assembly

**NOTE:** Front header shown, the rear header is assembled similarly.

#### ■ Oil Cooler and Filter Installation

1. With oil cooler and headers assembled, install assembly to left side of crankcase using

the hardware specified in Figure 8.14. Tighten bolts to standard torque values.

#### IMPORTANT

**INSTALL OIL COOLER ASSEMBLY USING NEW GASKET AT FRONT HEADER AND REAR FILTER-COOLER HEADER.**

2. Install new oil filter as follows:

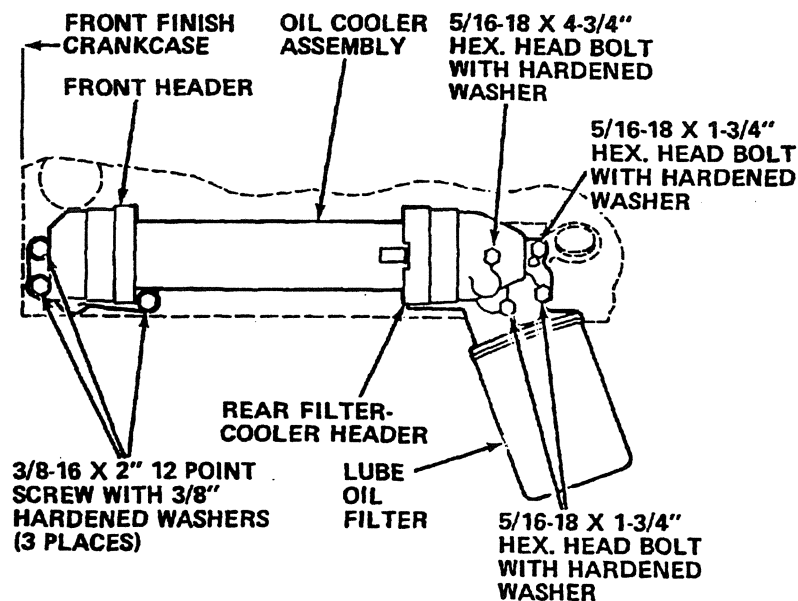
- Lubricate new filter gasket with clean engine oil.
- Hand-tighten filter 1-1/4 to 1-3/4 turns after gasket first contacts filter header.

#### CAUTION



**DO NOT OVERTIGHTEN FILTERS.**

**Damaged filters may fracture or leak.**



CG-11131A

Figure 8.14. Oil Cooler Assembly Instructions

## SERVICE MANUAL

### LUBRICATING OIL PUMP, OIL FILTER AND COOLER

#### OIL COOLER (Removal and Reassembly)

##### ■ Oil Cooler and Filter Installation – Continued

3. Prime the lubricating system as described in Section 6, "Crankshaft, Main Bearings, Flywheel and Crankcase".

##### ■ Lube Oil Recommendations

4. Fill the crankcase with 16 qts. (15.1 L) w/filter change (or 15 qts. [14.2 L] without filter change) of oil meeting the API (American Petroleum Institute) categories of both SG and CF-4 or CE (SG/CF-4 or SG/CE) and having Military Specification MIL-L-46152E and MIL-L-2104E approval. Do NOT use oils labeled as SG or CF-4 or CE only, as they could cause piston ring sticking or excessive valve train wear. Fleetrite Heavy Duty 30 Engine Oil is the preferred viscosity grade for 7.3 L diesel engines operating where the temperature will not be colder than +30°F (-1°C). When temperatures are expected to consistently remain below +30°F (-1°C) and above 0°F (-18°C) before the next oil change interval, SAE 15W-40 should be used for improved oil flow and cold starting. Refer to Chart 1. Shaded areas in Chart 1 indicate the preferred oil for the expected temperature range. CD engine oils should only be used when CF-4 or CE oils are NOT available in viscosity grades such as , 5W-30 and 10W-30, which are required for low temperature engine operation.

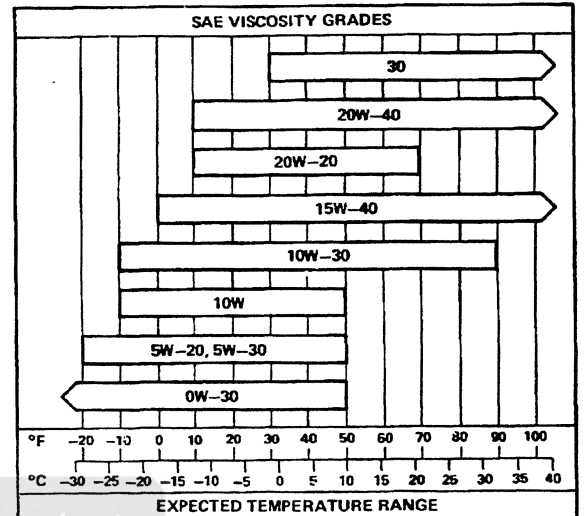
#### IMPORTANT

**ADD ONE (1) EXTRA QUART OF OIL  
IF OIL COOLER WAS REMOVED OR  
DRAINED OF OIL.**

#### IMPORTANT

**CHANGE THE ENGINE OIL AND FILTER  
EVERY 6000 MILES (9656 KM), 200  
HOURS OR 2 MONTHS, WHICHEVER  
OCCURS FIRST.**

CHART 1



CG-9893

#### NOTES:

1. SAE 30 is the preferred viscosity grade for 7.3 liter diesel engines for all operating conditions where the temperature will not be colder than +30°F (-1°C). Use SAE 15W-40 when temperatures consistently remain below +30°F (-1°C).
2. Some increase in oil consumption may be expected when SAE OW-30, 5W-20, 5W-30, 10W, and 10W-30 oils are used. Check oil level more frequently.
3. SAE 5W-20 oils are NOT recommended for continuous, high speed operation.
4. Do not use the low viscosity oils (SAE 10W, 5W-20, 5W-30 and OW-30) when the temperature is consistently above +50°F (+10°C), as higher engine wear and engine damage may occur.
5. Start the engine and check for leaks, correct as necessary. Shut engine down and recheck oil level. Add oil (if needed) or drain oil (if needed to bring oil level to "FULL" mark on oil level gauge,

**NOTE: Do not "overfill" past the full mark.**

# **SERVICE MANUAL**

## **INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS**

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**FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS**

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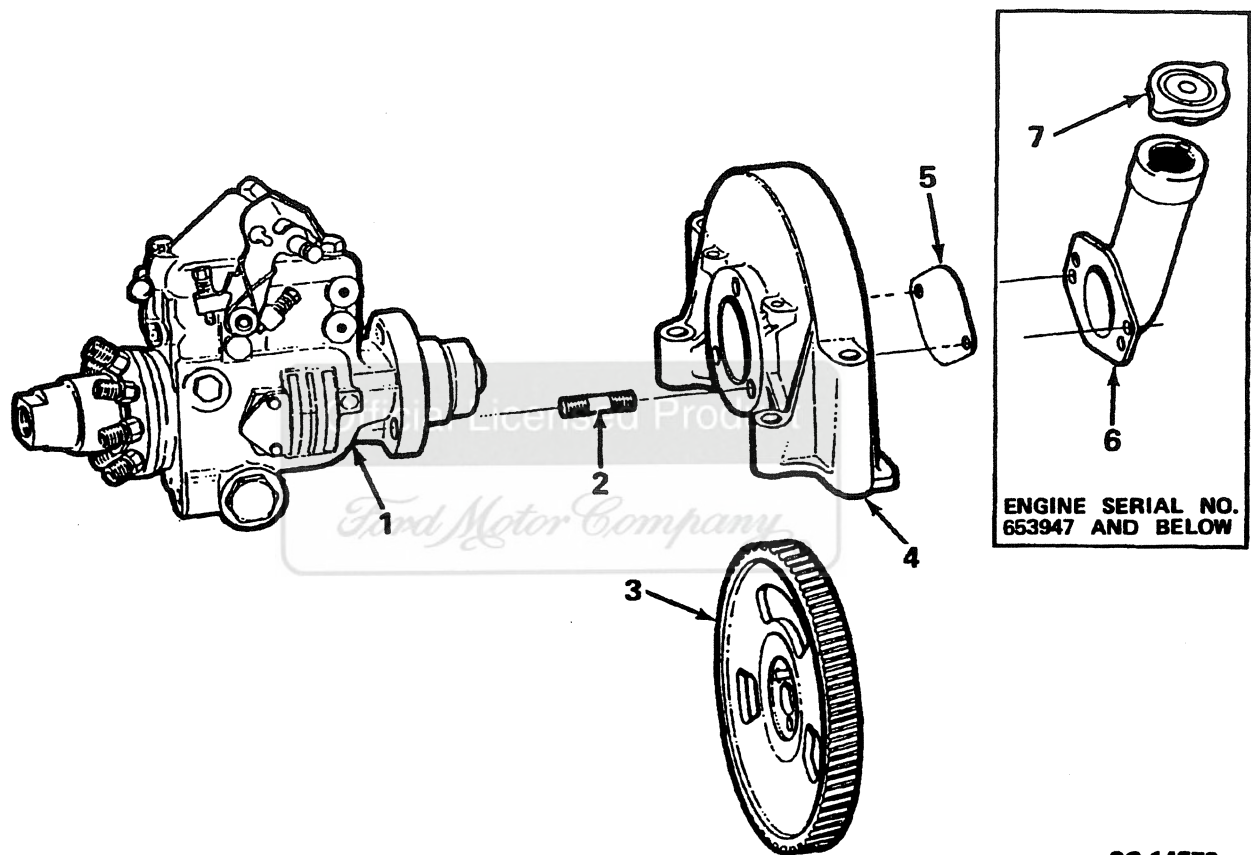
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# SERVICE MANUAL

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Figure 9.1. Injection Pump Mounting  
[All Applications]

1. Injection Pump
2. Mounting Stud
3. Drive Gear
4. Adapter Housing

5. Cover Plate [1989 MY and Later]
6. Oil Filler Elbow Assy [1988 MY & Earlier]
7. Oil Filler Cap

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

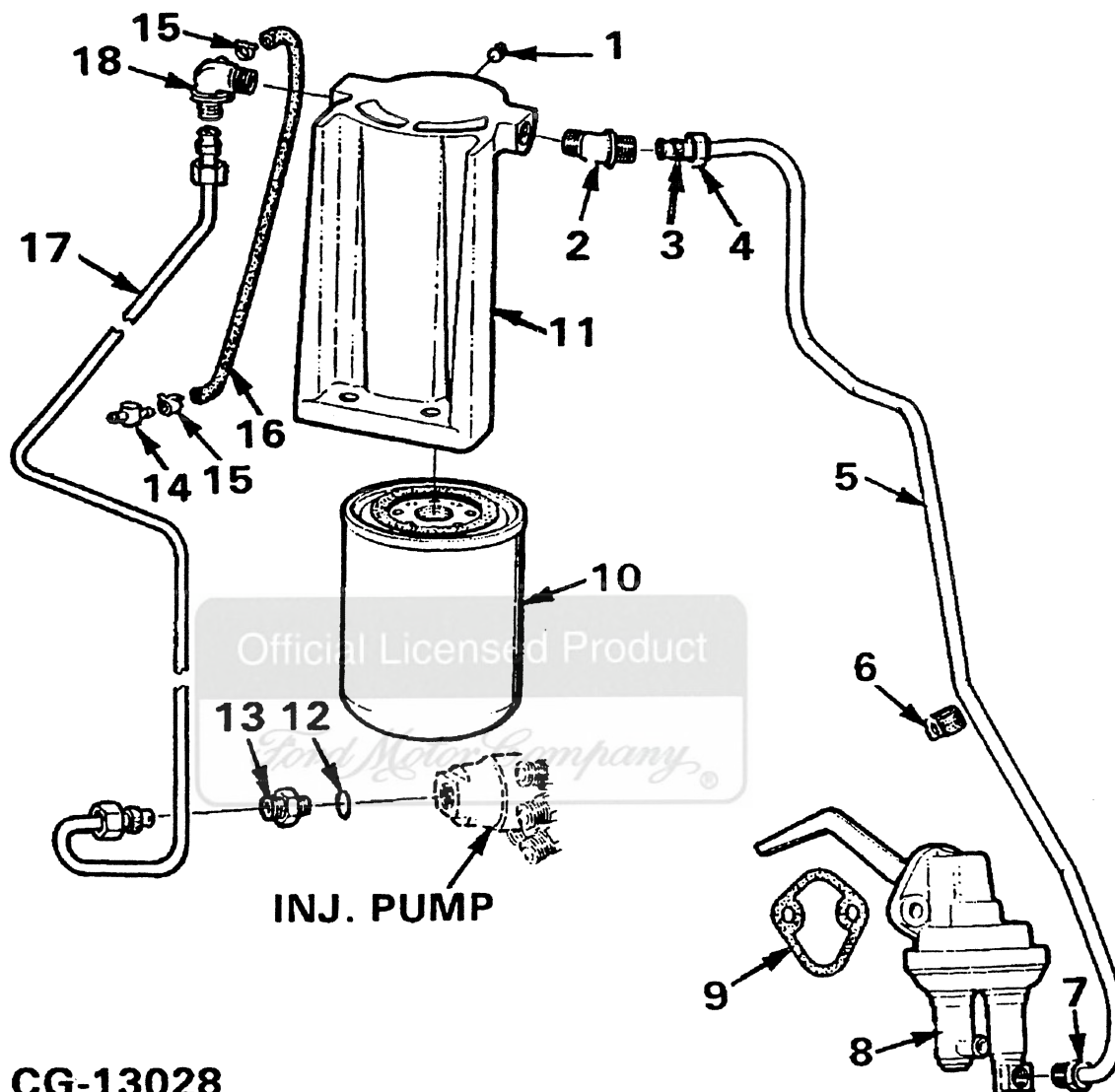


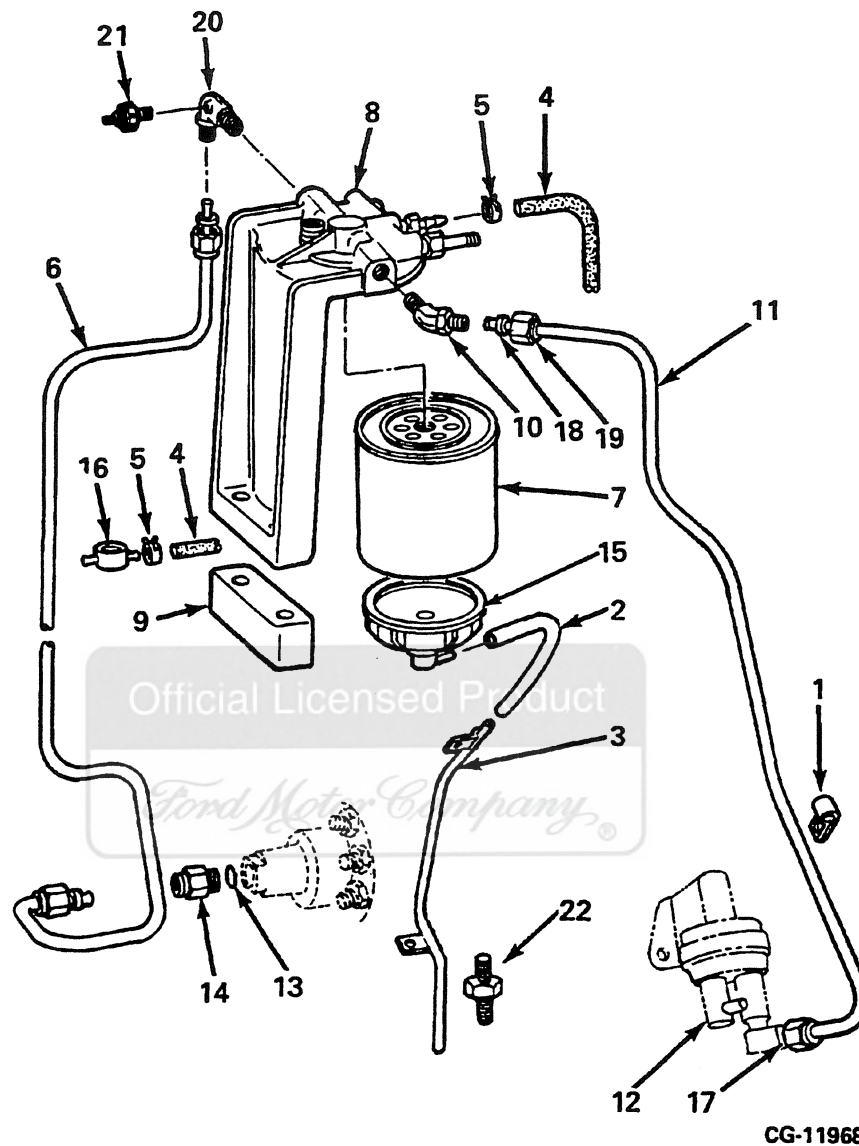
Figure 9.2A. Fuel Filter and Supply Pump Assembly  
[All Applications Except U-Haul]

- |                            |   |
|----------------------------|---|
| 1. Pipe Plug               | 11. Fuel Filter Header  |
| 2. Elbow                   | 12. O-Ring  |
| 3. Sealing Ring            | 13. Connector Fitting   |
| 4. Tube Nut                | 14. Fuel Return Tee   |
| 5. Tube Assembly           | 15. Fuel Return Hose Clip                                       |
| 6. Clamp                   | 16. Hose, 3/16" ID x 10" Long                                   |
| 7. Inverted Flare Tube Nut | 17. Filter to Injection Pump Tube<br>w/Two Nuts and Two Sleeves |
| 8. Fuel Supply Pump        | 18. Elbow with Bleed-Off  |
| 9. Fuel Supply Pump Gasket |   |
| 10. Final Fuel Filter      |   |

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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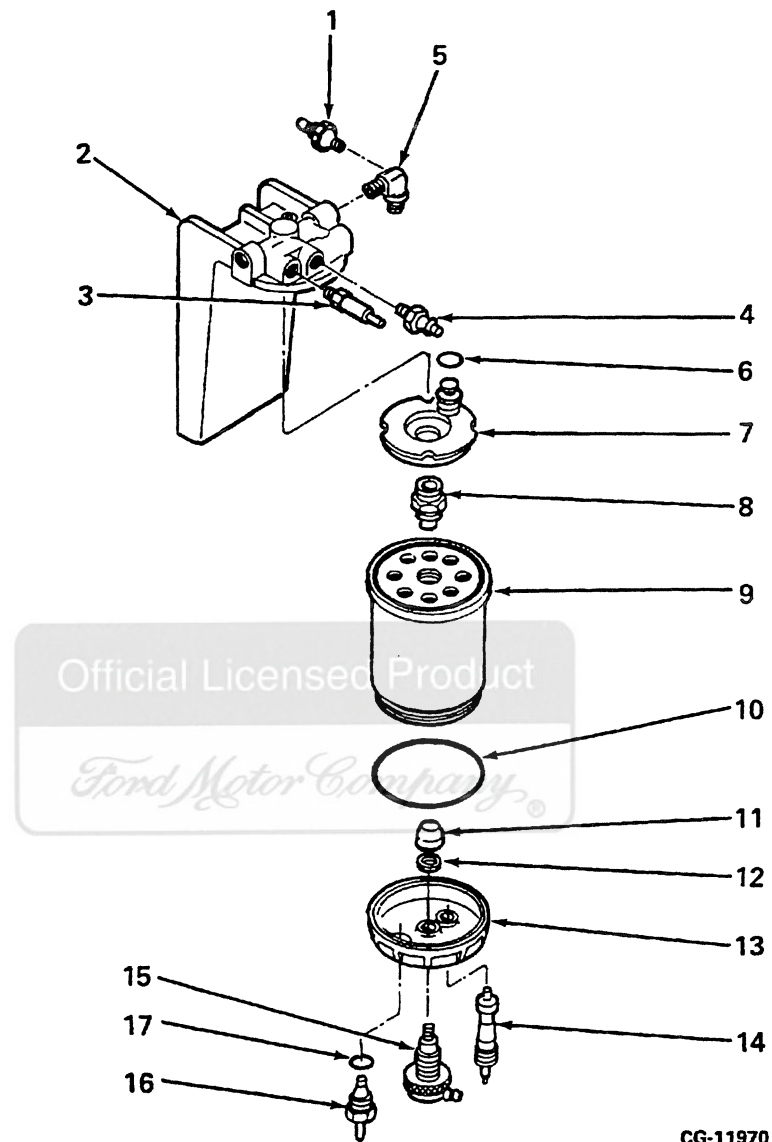


**Figure 9.2B. Fuel Filter/Water Separator/Heater and Fuel Supply Pump Assembly  
[U-Haul Applications Only]**

- |  |                                |
|--|--------------------------------|
| 1. Clamp   | 12. Fuel Supply Pump           |
| 2. Drain Hose  | 13. Sealing "O" Ring           |
| 3. Drain Tube w/Clamps   | 14. Connecting Fitting         |
| 4. Filter Fuel Return Hose                                       | 15. Water Separator Drain Bowl |
| 5. Hose Clip   | 16. Fuel Return Tee            |
| 6. Filter to Injection Pump Tube (w/two<br>nuts and two sleeves) | 17. Inverted Flare Tube Nut    |
| 7. Fuel Filter Element   | 18. Sealing Ring               |
| 8. Fuel Filter Base/Header                                       | 19. Tube Nut                   |
| 9. Filter Base Spacer  | 20. Male Elbow                 |
| 10. Elbow  | 21. Vacuum Switch              |
| 11. Fuel Pump to Filter Tube (w/two<br>nuts and one sleeve)      | 22. Exhaust Manifold Stud      |

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS



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**Figure 9.2C. Fuel Filter, Fuel Heater and Water Separator Assembly  
[U-Haul Applications Only]**

- |  |  |
|--|--|
| 1. Vacuum Switch (Fuel Filter Element Replacement Indicator) | 10. "O" Ring, Drain Bowl                             |
| 2. Fuel Filter Base and Header                               | 11. Cap Nut, Drain Valve Stem                        |
| 3. Fuel Priming Valve w/Cap                                  | 12. Seal, Drain Valve                                |
| 4. Continuous Vent w/Check Valve                             | 13. Water Separator Drain Bowl                       |
| 5. Male Elbow  | 14. Vent Valve Assembly<br>(Not Serviced Separately) |
| 6. Fuel Heater "O" Ring                                      | 15. Drain Valve Assembly                             |
| 7. Fuel Heater   | 16. Probe, Water Sensor                              |
| 8. Threaded Insert   | 17. "O" Ring, Water Sensor                           |
| 9. Fuel Filter Element                                       |  |

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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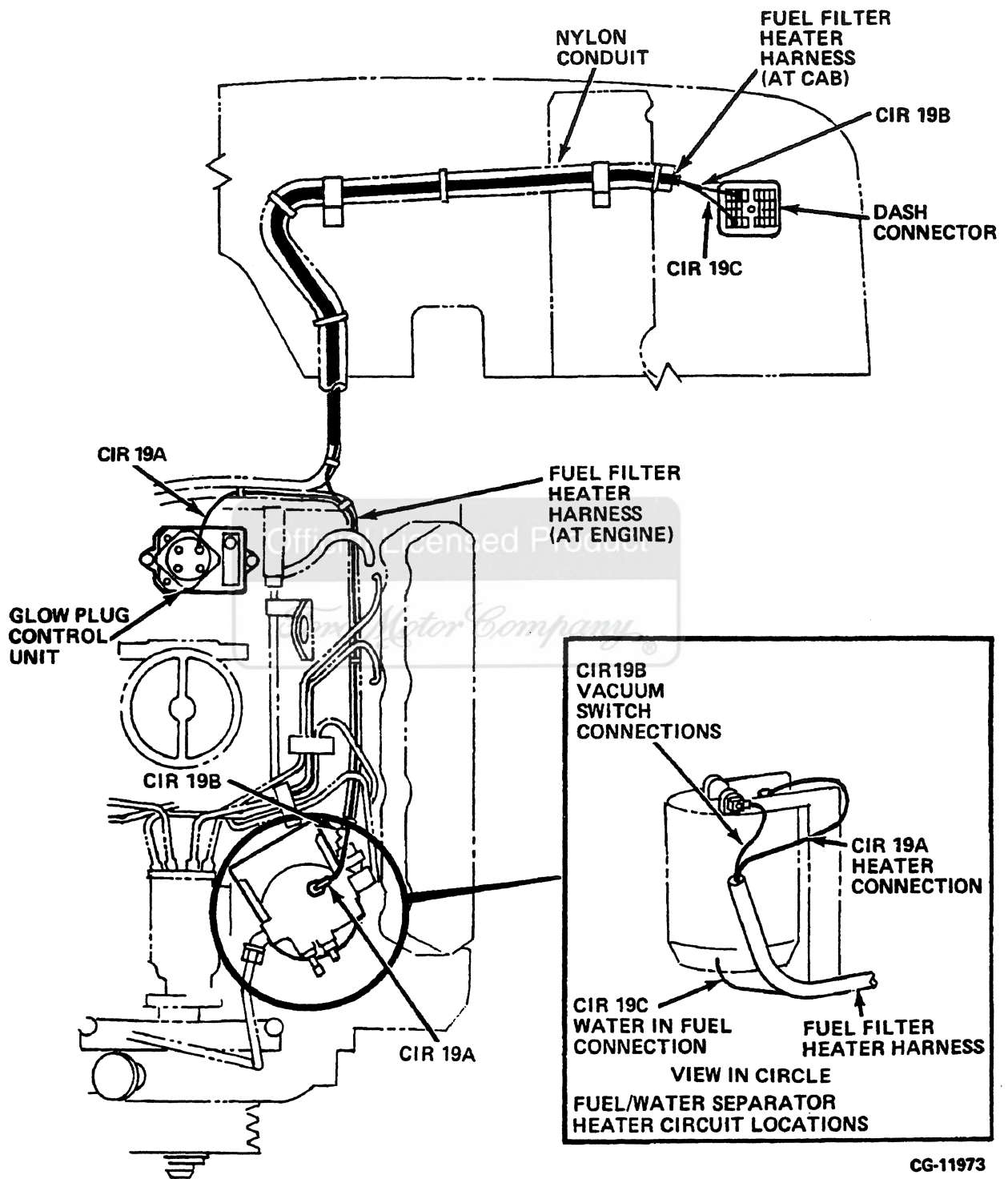
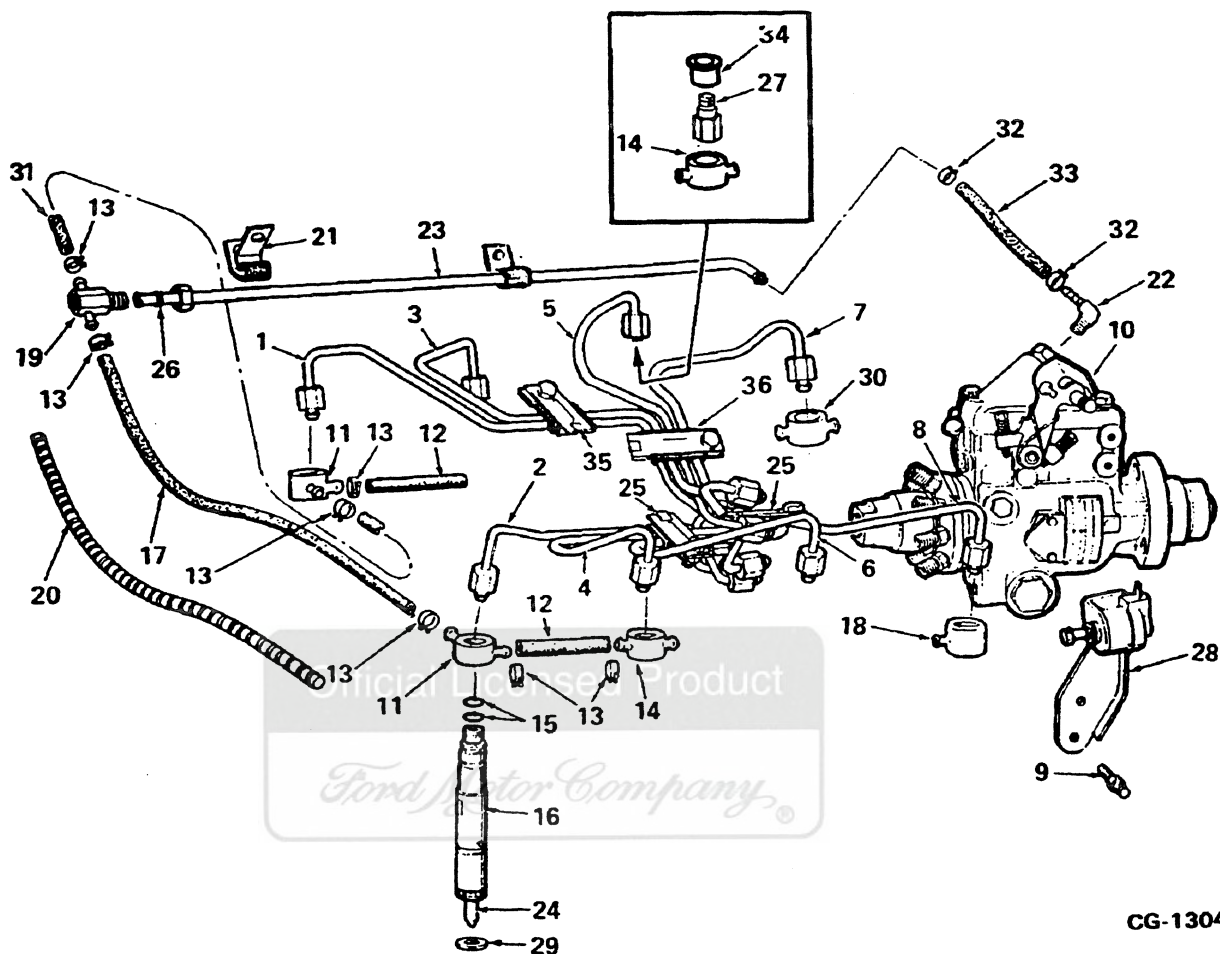


Figure 9.2D. Fuel Filter/Water Separator/Heater Connections



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS



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Figure 9.3. Injection Pump, Nozzles and Piping  
[All Applications]

- |                               |                                     |   |
|-------------------------------|-------------------------------------|---|
| 1. Pipe w/Nuts Pump to Cyl. 8 | 16. Injection Nozzle & Holder Assy. | 26. Sealing Ring  |
| 2. Pipe w/Nuts Pump to Cyl. 7 | 17. Fuel Return Hose                | 27. Fuel Injection Line Pressure Sensor (at No. 4 Cyl.) |
| 3. Pipe w/Nuts Pump to Cyl. 6 | 18. Fuel Return Elbow               | 28. Fast Idle Solenoid and Bracket                      |
| 4. Pipe w/Nuts Pump to Cyl. 5 | 19. Fuel Return Junction Fitting    | 29. Nozzle Gasket (Copper)                              |
| 5. Pipe w/Nuts Pump to Cyl. 4 | 20. Fuel Return Rear Hose Guard     | 30. Fuel Return Tee                                     |
| 6. Pipe w/Nuts Pump to Cyl. 3 | 21. Fuel Return Tube Clamp          | 31. Fuel Return Hose                                    |
| 7. Pipe w/Nuts Pump to Cyl. 2 | 22. Fuel Return Elbow (at Pump)     | 32. Fuel Return Hose Clamp (at Pump)                    |
| 8. Pipe w/Nuts Pump to Cyl. 1 | 23. Fuel Return Tube w/Clamp        | 33. Fuel Return Hose                                    |
| 9. Spring Anchor              | 24. Nozzle Tip                      | 34. Line Pressure Sensor Cover                          |
| 10. Injection Pump Assembly   | 25. Injection Pipe Clamp (3 Gang)   | 35. Injection Pipe Clamp (2 Gang)                       |
| 11. Fuel Return Injector Tee  |                                     | 36. Injection Pipe Clamp (4 Gang)                       |
| 12. Fuel Return Hose          |                                     |   |
| 13. Hose Clip                 |                                     |   |
| 14. Fuel Return Tee           |                                     |   |
| 15. O-Rings                   |                                     |   |

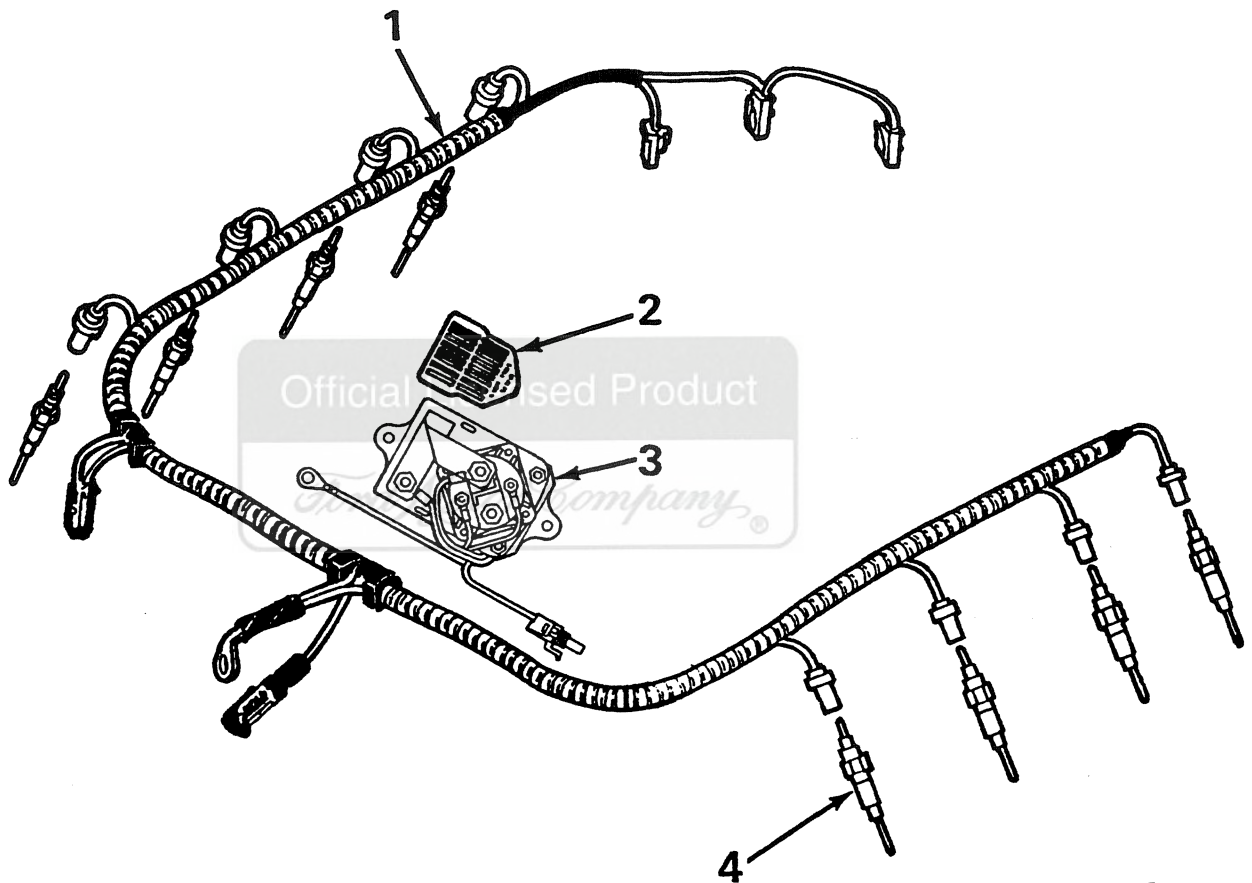
### NOTE

Refer to the current parts catalog (1 171 604 R4 or later) for detailed descriptions and hose lengths.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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Figure 9.4. Glow Plugs and Harness  
[All Applications]

- 1. Glow Plug Harness
- 2. Glow Plug Controller Cover

- 3. Glow Plug Controller
- 4. Glow Plug (8 Quantity)

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

### SPECIFICATIONS

#### INJECTION PUMPS

Model .....	Stanadyne DB-2
Drive .....	Gear – Steel Forging
Static Timing .....	Marks Aligned
Minimum Voltage to Pump .....	9 Volts

#### NOZZLES

Type .....	Pintle
Size .....	17 mm
Actuation .....	High Pressure Fuel from Fuel Injection Pump
Pintle Hole:	
Number .....	1
Hole Diameter .....	0.039 in. (1.0 mm)
Valve Seat Angle .....	60°
Valve Opening Pressure (VOP)	
New .....	1875±75 psi (12,928±517 kPa)
Min. VOP before Replacement .....	1425 psi (9825 kPa)

#### FUEL SUPPLY PUMP

Type .....	Mechanical Diaphragm
------------	----------------------

#### FUEL FILTER

Type .....	Spin-On
------------	---------

#### GLOW PLUGS

Location .....	Cylinder Head
Quantity .....	8
Thread Size .....	M10 X 1 (SAE J5480)

### SPECIAL TORQUES

Glow Plug .....	12 lbf-ft. (16 N•m)
Injection Pump Gear Cover Bolt* .....	14 lbf-ft. (19 N•m)
Injection Pump Gear Mounting Bolt .....	25 lbf-ft. (34 N•m)
Injection Nozzle .....	35 lbf-ft. (47 N•m)
Injection Pipe Nut .....	22 lbf-ft. (30 N•m)
Injection Line Pressure Sensor .....	28 lbf-ft. (38 N•m)
Nozzle Cap Nut .....	33 lbf-ft. (45 N•m)

\*Apply R.T.V. to all threads of bolts prior to assembly.

### SPECIAL SERVICE TOOLS

<u>Tool No.</u>	<u>Description</u>
ZTSE-4132	Injection Pump Wrench
ZTSE-4133	Fuel Line Wrench
ZTSE-4135	Fuel System Protector Cap Set
ZTSE-4139	Nozzle Seat Cleaner
ZTSE-4141	Nozzle Holder Rack
ZTSE-4142	Tach-N-Time Diesel Timing Tester
ZTSE-4045-A	Nozzle Tester
SE-2202(†)	Nozzle Cleaning Kit
SE-2250(†)	Lapping Blocks

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### COMPONENT IDENTIFICATION

#### ● FUEL INJECTION PUMPS

Identification of injection pump is best made by obtaining injection pump part number which is stamped on name plate located on "control lever side" of pump housing. Refer to **Figure 9.5**.

The name plate shows pump model in code form and indicates pump characteristics. Example of code shown below:

DB2 – D Series Pump, B Rotor, 2 Second generation.

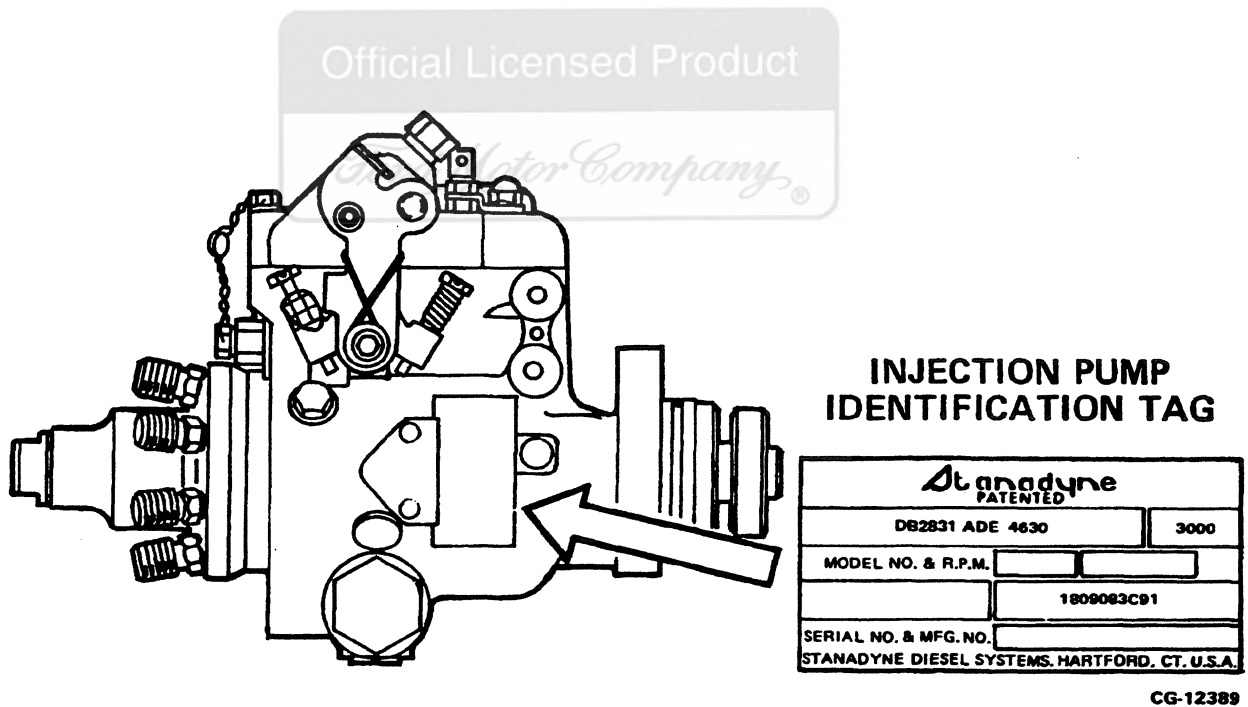
8 – Number of cylinders

31 – Abbreviation of Plunger diameter  
(.310in. [7.87mm])

ADE – Accessory code

4630 – Specification Number, determines selection of parts and adjustments for a given application.

Refer to "STANADYNE MODEL DB2 FUEL INJECTION PUMP" Service Manual CGES-475\* for servicing of injection pump.



**Figure 9.5. Injection Pump I.D. Tag Location**  
[All Applications]

\* – Manual number specified with latest revision.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

### COMPONENT IDENTIFICATION - Continued

#### ● Nozzle and Holder Assemblies

#### IMPORTANT

Effective with engine serial No. 622179 and above, Stanadyne nozzle and holder assemblies are available as an alternate source to CAV nozzle and holder assemblies.

#### IMPORTANT

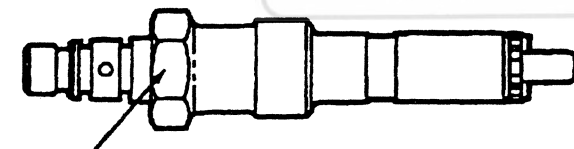
Prior to the release of the Stanadyne nozzle and holder assemblies only CAV nozzle and holder assemblies were used in production and service. Nozzle and holder assembly identification is made by the nozzle code located on the nozzle holder body flats. Refer to Figure 9.6A.

When replacing one or more nozzle and holder assemblies it is acceptable to intermix "BB", "C" or "D" code, nozzle assemblies within an engine. However, DO NOT intermix individual service repair parts between CAV "BB" code and Stanadyne "C" or "D" code nozzles. Refer to the Parts Affected Section for the correct service part identification. Refer to Figure 9.6B.

#### IMPORTANT

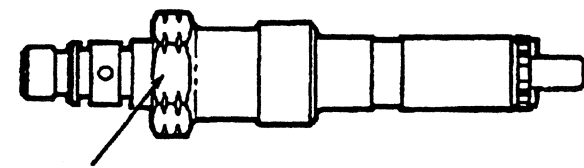
Do not attempt to install a "BB" nozzle tip assembly into a "C" or "D" code nozzle holder or a "C" or "D" code nozzle tip assembly into a "BB" code nozzle holder. This type of intermixing is inappropriate due to vendor manufacturing differences.

#### STANADYNE NOZZLE & HOLDER ASSEMBLY



STAMPED  
CODE  
LOCATION  
C or D

#### CAV NOZZLE & HOLDER ASSEMBLY

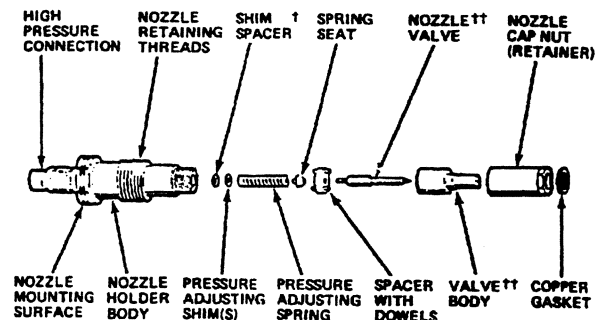


STAMPED  
CODE  
LOCATION  
BB

CG-13331

Figure 9.6A. Nozzle and Holder Assembly  
Part No. Identification [All Applications]

The Stanadyne "C" and "D" Code nozzles have no notches on the nozzle holder body flats. The CAV "BB" nozzles have two notches at each flat. This provides quick vendor identification.



† USED ON STANADYNE "C" AND "D" CODE NOZZLE ONLY.  
"BB" CODE NOZZLES USE PRESSURE ADJUSTING SHIM(S)  
WITHOUT SPACERS.

†† NOZZLE VALVE AND VALVE BODY CREATE THE NOZZLE  
TIP ASSEMBLY.

CG-14521

Figure 9.6B. Nozzle and Holder Assembly -  
Exploded View  
[All Applications]



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL FILTER ASSEMBLY

(Removal & Reassembly)

[All Applications Except U-Haul]

**NOTE:** Prior to injection pump removal, thoroughly clean the injection pump, injection nozzles, fuel pump and fuel lines to prevent contamination of the fuel system. Refer to exploded views. **DO NOT CLEAN WITH ENGINE RUNNING.**

#### ■ Removal

(Refer to Figure 9.7)

1. Loosen and remove the fuel inlet tube (from supply pump to fuel filter) retaining clamp (6) at the water pump housing bolt.

2. Loosen the inverted flare tube nut (7) at the fuel supply pump (8) and tube nut (4) at elbow (2) near the filter base (11).

**NOTE:** Remove and discard the rubber sealing ring (3) at the tube nut (4). Use a new sealing ring during installation.

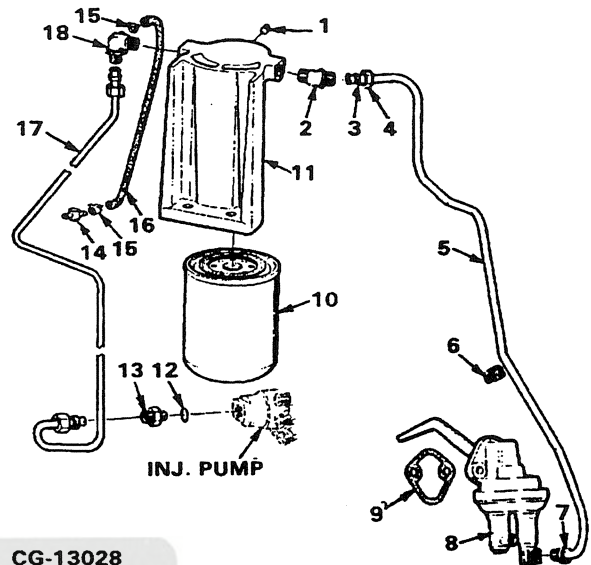
3. Remove the fuel return hose (16) (leak-off) using pliers to loosen the two clips (15). Remove the hose from the filter base (11) and fuel return tee (14).

4. Remove the filter to injection pump tube (17) as follows:

- Loosen and remove the connector nut at the filter base elbow (18) and discard rubber sealing ring.
- If removing injection pump, loosen and remove the connector nut at the injection pump inlet connector fitting (13). Discard rubber sealing ring and cap pump opening.

5. Remove the fuel filter (10) from the filter base (11) and discard the filter element.

6. Remove the filter base (11) by removing the two nuts which retain the filter base on the intake manifold. Lift the filter base from the intake manifold studs.



CG-13028

Figure 9.7. Fuel Filter and Fuel Supply Pump Assembly

1. Pipe Plug
2. Elbow
3. Sealing Ring
4. Tube Nut
5. Tube Assembly
6. Clamp
7. Inverted Flare Tube Nut
8. Fuel Supply Pump
9. Fuel Supply Pump Gasket
10. Final Fuel Filter
11. Fuel Filter Header
12. O-Ring
13. Connector Fitting
14. Fuel Return Tee
15. Fuel Return Hose Clip
16. Hose, 3/16 I.D. x 10" Long
17. Filter to Injection Pump Tube w/Two Nuts and Two Sleeves
18. Elbow with Bleed-Off

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL FILTER ASSEMBLY – Continued (Removal & Reassembly)– Continued [All Applications Except U-Haul]

##### ■ Cleaning

1. Clean all parts in clean diesel fuel.
2. Dry with filtered compressed air.

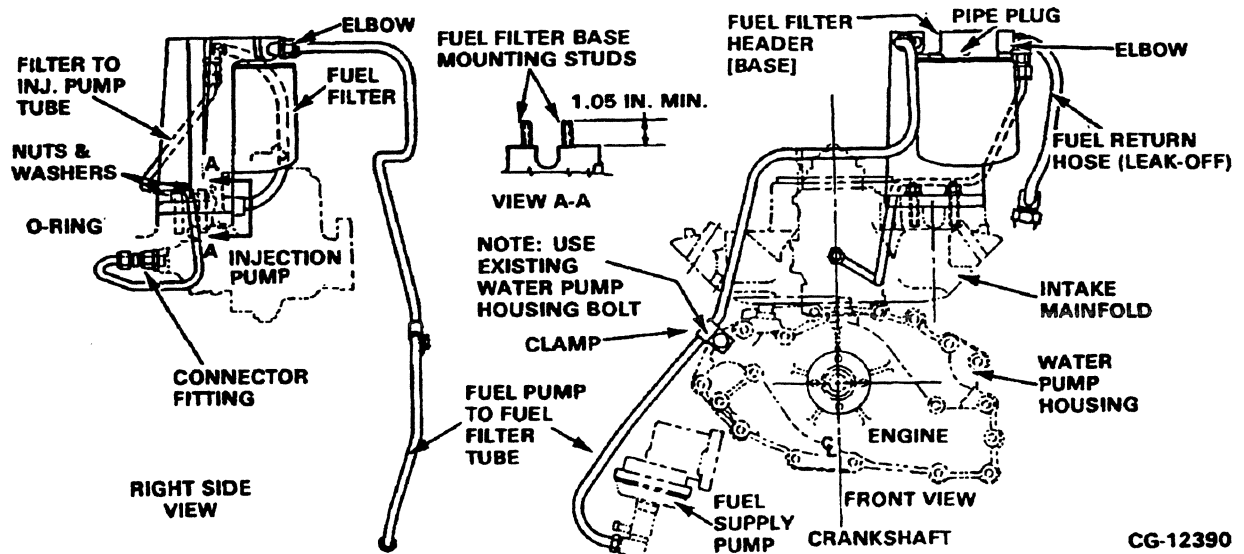
##### ■ Inspection

1. Visually inspect all tubes for blockage and/or kinks which may cause a restriction in fuel flow. Replace as required.
2. Visually examine all fittings for thread damage. Replace component as required.
3. Replace all rubber sealing rings with new, prior to reassembly.

##### ■ Reassembly

(See Installation Diagram, Figure 9.8)  
(Ref. Nos. Refer to Figure 9.7)

1. Install filter base (11) on intake manifold mounting pad and fasten using two nuts with washers.
2. Install new rubber sealing rings and connect the filter to injection pump tube (17) to the connector fitting (13) at the injection pump inlet and to the elbow (18) at the filter base.
3. Connect the fuel return hose (16) to the filter base (11) and the fuel return tee (14) using clips (15).
4. Connect the supply pump to filter base tube (5), using a new sealing ring (3) at the filter base elbow (2). Tighten tube nut (4) and inverted flare tube nut (7). Attach clamp (6) to water pump bolt.
5. Install a new final fuel filter (10) as follows:
  - a. Assure mounting pad is clean.
  - b. Coat the gasket of the final filter with clean fuel.
  - c. Tighten until the gasket touches the filter header.
  - d. Tighten an additional 1/2 turn.



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Figure 9.8. Fuel Filter Piping Installation

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

Section 9  
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### FUEL FILTER/WATER SEPARATOR ASSEMBLY (Removal & Reassembly) [U-Haul Applications Only]

**NOTE:** Prior to injection pump removal thoroughly clean the injection pump, injection nozzles, fuel filter assembly and fuel lines to prevent contamination of the fuel system. Refer to exploded views. **DO NOT CLEAN WITH ENGINE RUNNING.**

#### • REMOVAL

Refer to Figure 9.2B

1. Loosen and remove the fuel inlet tube (from supply pump to fuel filter) retaining clamp (1) at the water pump housing bolt.
2. Loosen the inverted flare tube nut (17) at the fuel supply pump (12) and tube nut (19) at elbow (10) on the filter base header (8).

**NOTE:** Remove and discard the rubber sealing ring (18) at the tube nut (19). Use a new sealing ring during installation.

3. Remove the fuel return hose (4) (leak-off) using a pliers to loosen the two clips (5). Remove the hose from the filter base (8) and fuel return tee (16).
4. Remove the filter to injection pump tube (6) as follows:
  - Loosen and remove the connector nut at the filter base elbow (2) and discard rubber sealing ring.
  - If removing injection pump, loosen and remove the connector nut at the injection pump inlet connector fitting (14). Discard rubber sealing ring and cap pump opening.
5. Disconnect the electrical connections at the water sensor probe, vacuum switch and heater wire.
6. Remove the water drain tube and hose assembly as follows:
  - Loosen and remove the nuts and washers which clamp the tube at the valve cover and exhaust manifold.
  - Disconnect the hose (2) and tube (3) assembly from the drain bowl connection.

7. Remove the fuel filter/water separator element (7) from the filter base/header (8). Disassemble the water separator drain bowl (13, Figure 9.2C) from the filter element, using two filter wrenches. Discard the element (7) and drain bowl "O" ring (10, Figure 9.2C). Retain the drain bowl.

8. Remove the filter base (8) by removing the two nuts which retain the filter base to the intake manifold. Lift the filter base off the intake manifold studs.

#### • CLEANING

1. Clean all parts in clean diesel fuel.
2. Dry with filtered compressed air.

#### • INSPECTION

1. Visually inspect all tubes for blockage and/or kinks which may cause a restriction in fuel flow. Replace as required.
2. Visually examine all fittings for thread damage. Replace component as required.
3. Replace all rubber sealing rings with new, prior to reassembly.

#### • REASSEMBLY

(See Installation Diagram, Figure 9.9)  
(Ref. Nos. Refer to Figure 9.2B)

1. Install the filter base spacer (9) and filter base/header on the intake manifold mounting pad and fasten using two nuts with washers.
2. Install new rubber sealing rings and connect the filter to the injection pump tube (6) to the connector fitting (14) at the injection pump inlet and to the elbow (20) at the filter base.
3. Connect the fuel return hose (4) to the filter base (8) and the fuel return tee (16) using clips (5).
4. Connect the supply pump to filter base tube (11), using a new sealing ring (18) at the filter base elbow (10). Tighten the tube nut (19) and inverted flare tube nut (17). Attach the clamp (1) to the water pump bolt.

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL FILTER/WATER SEPARATOR ASSEMBLY (Removal & Reassembly) – Continued [U-Haul Applications Only]

5. Install a new fuel filter/water separator (7) as follows:

- Assure mounting pad is clean.
- Install a new drain bowl "O" ring (10, **Figure 9.2C**) at the drain bowl.
- Coat the drain bowl "O" ring with clean fuel and install drain bowl to filter element (7), by hand, until "O" ring contacts, then turn an additional 1/2 turn.
- Coat the gasket of the filter with clean fuel.

e. Tighten until the gasket touches the filter header.

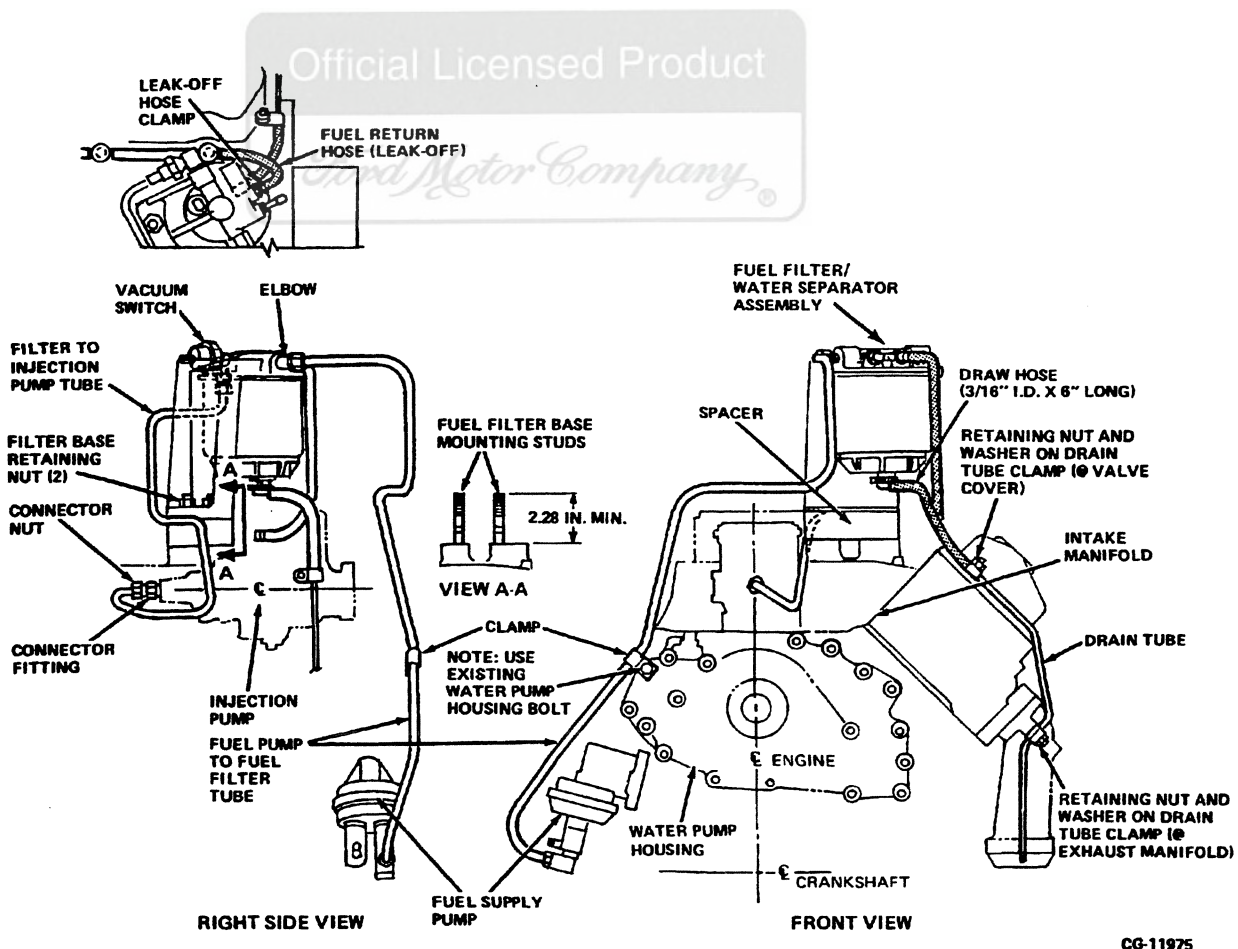
f. Tighten the filter element an additional 1/2–3/4 turn.

6. Connect the water drain tube (3) and hose (2) to the valve on the drain bowl. Fasten the drain tube at the valve cover and at the exhaust manifold.

7. Reconnect the electrical connectors at the water sensor, vacuum switch and heater probe.

8. The drain valve must be closed, tighten by turning clockwise (facing bottom of drain bowl) until a positive stop is felt.

9. Check for leaks after the engine has been started.



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Figure 9.9. Fuel Filter/Water Separator Piping Installation



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### ● DIAGNOSTICS

##### Fuel Heater

**PROBLEM:** Suspect inoperative fuel heater (circuit not closing).

**PROCEDURE:** (Refer to Figure 9.10)

1. Disconnect harness lead at fuel heater.
  - a. Connect a test lamp lead to the female socket of the fuel heater harness lead and ground the other end of the test lamp.
  - b. Turn ignition key to "ON" position and check for power.
    - Test lamp lights, circuitry to heater is OK.
    - Test lamp **DOES NOT LIGHT**, check the fuse.
      - Fuse OK, repair wiring.
      - Fuses not OK, replace fuse and recheck system.
      - If the fuse opens again, repair wiring.
2. Check fuel heater operation using a test lamp, as follows:
  - a. Connect a test lamp in series with the fuel heater (one end to fuel heater and the other to the heater pin connector).
  - b. Turn ignition key to "ON" position.
  - c. Apply Freon, Freeze Spray or Dry Ice (only required if the engine is above 30°F) to the fuel filter/water separator header.

**NOTE:** A heavy application of Freon, Freeze Spray or dry ice must be applied to the header to perform this test. A thick layer of "frost" must accumulate on the header to assure proper cooling. Freeze Spray is available through most electronics suppliers.

#### CAUTION



USE FREON OR FREEZE SPRAY WITH CARE. AVOID CONTACT WITH SKIN AND EYES. WEAR SAFETY GLASSES. WEAR GLOVES IF HANDLING DRY ICE.

#### IMPORTANT

Regular ice will NOT cool the engine components enough to perform this test. Do not operate the engine at least 4 hours prior to testing or to expedite the heater test, cool the fuel filter/header assembly in a freezer as follows:

1. Remove the filter/water separator assembly from the engine and cap all open lines at the injection pump and engine.
2. Drain the fuel from the filter using the drain valve in the drain bowl.
3. Connect an OHM meter to the fuel heater connector pin and ground on the header/base.
4. Place the fuel filter/water separator assembly in a freezer. The OHM meter will indicate an open circuit at room temperature or a closed circuit when the heater has reached its activation temperature.
5. After the heater has been activated, quickly remove the heater from the freezer and reinstall the fuel filter/header assembly to the engine. Test on engine using the test lamp as described (2a-c).

#### RESULT/CORRECTIVE ACTION:

- Test lamp lights, heater is operational.
- Fuse opens, replace heater.

**NOTE:** Lamp should light within 10 minutes of proper cooling. If the engine is below 30°F the test lamp will be on all the time.

- Test lamp **DOES NOT** light, replace fuel heater.

**NOTE:** Refer to disassembly instructions under "REASSEMBLY" in this section.

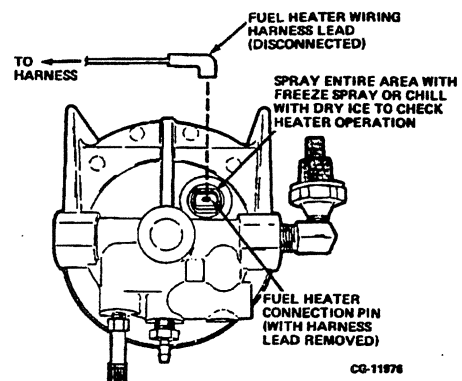


Figure 9.10. Fuel Heater Lead Location for Diagnostic Testing



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • DIAGNOSTICS - Continued

##### Vacuum Switch

**NOTE:** The vacuum switch activates a fuel filter restriction warning lamp", on the instrument panel, indicating the need for filter element replacement.

**PROBLEM:** Warning lamp stays on (even with key on engine not running)

##### PROCEDURE:

1. Disconnect the vacuum switch wiring harness lead at the vacuum switch.
2. Turn the ignition key to "ON" position.

##### RESULT/CORRECTIVE ACTION:

- Lamp goes "OFF", replace the vacuum switch.
- Lamp stays "ON", check for a short to ground in the wiring from the vacuum switch to the bulb.

**PROBLEM:** Suspect inoperative restriction indication.

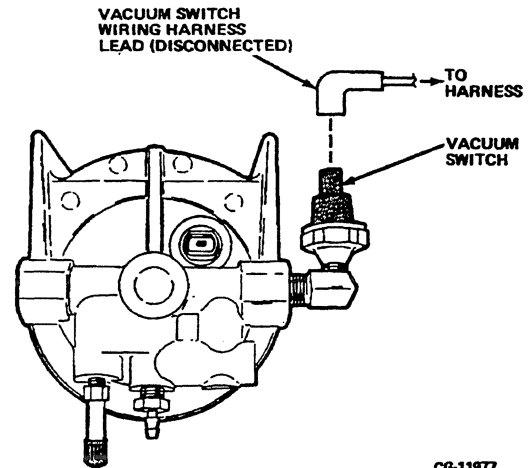
##### PROCEDURE:

1. Turn ignition key to "START", position.

##### RESULT/CORRECTIVE ACTION:

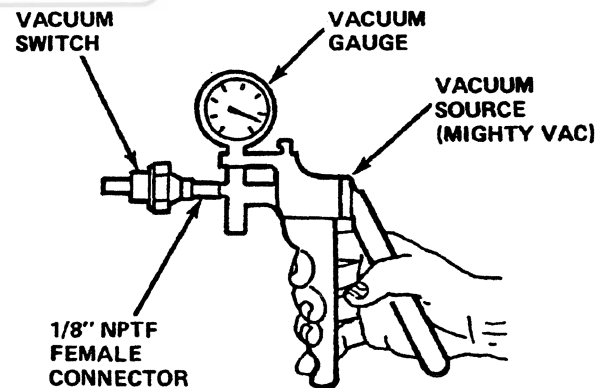
- Dash lamp "OFF" (does not light), replace bulb.
- Dash lamp "ON" (lights up), remove vacuum switch lead and ground the lead. (Refer to Figure 9.11).

- With ignition key in "ON", position, the dash lamp will either be "ON" or "OFF".
- If dash lamp is "OFF", check the circuit for open wiring.  
(Switch Operational Check)
- If dash lamp is "ON", remove the vacuum switch from the fuel filter header and apply a vacuum of 7 in. Hg.  $\pm$  1.5.
- If vacuum does NOT hold, replace the vacuum switch. Refer to Figure 9.12A.



CG-11977

Figure 9.11. Vacuum Switch Lead Location For Diagnostic Testing



**NOTE:** VACUUM DECAY SHOULD NOT OCCUR. MUST HOLD 7 IN. Hg.  $\pm$  1.5.

CG-11426

Figure 9.12A. Checking Vacuum Switch for Leakage

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

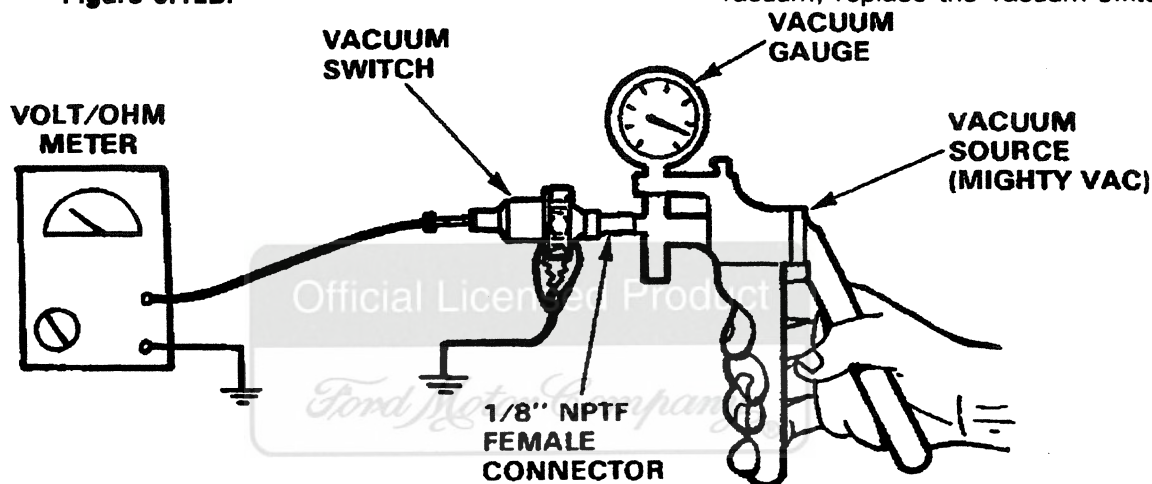
#### ● DIAGNOSTICS - Continued

##### Vacuum Switch - Continued

- If vacuum does hold, verify that the switch is operational (comes on) at the correct vacuum specification. Refer to Figure 9.12B.

- Check continuity by connecting a volt/ohm meter to the switch and applying 7 in. Hg.  $\pm$  1.5 vacuum, as shown in Figure 9.12B.

- If no continuity at 7 in. Hg.  $\pm$  1.5 vacuum, replace the vacuum switch.



**NOTE: APPLY A VACUUM  
OF 7 IN. Hg.  $\pm$  1.5. AND  
CHECK CONTINUITY.**

CG-12435

Figure 9.12B. Checking Vacuum Switch for Continuity

#### Continuous Vent and Check Valve Assembly

**PROBLEM:** Suspect blocked orifice at continuous vent.

**PROCEDURE:** (Refer to Figure 9.13)

1. Disconnect fuel return hose at the vent fitting on fuel filter header.
2. Install a suitable length of test hose onto the vent fitting with open end of hose in a container (to catch fuel).
3. Start the engine.

#### RESULT/CORRECTIVE ACTION:

- Fuel flows into the container, the vent w/check valve is O.K. (Fuel leak-off rate is approximately 1 gal./hour).
- If no fuel flow is observed, replace the continuous vent w/check valve assembly.

**PROBLEM:** Suspect return fuel is drawn into the intake system. (NOTE: This is possible if the check valve is defective and there is an inoperative fuel supply pump or if fuel inlet restriction is excessive.)

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • DIAGNOSTICS - Continued

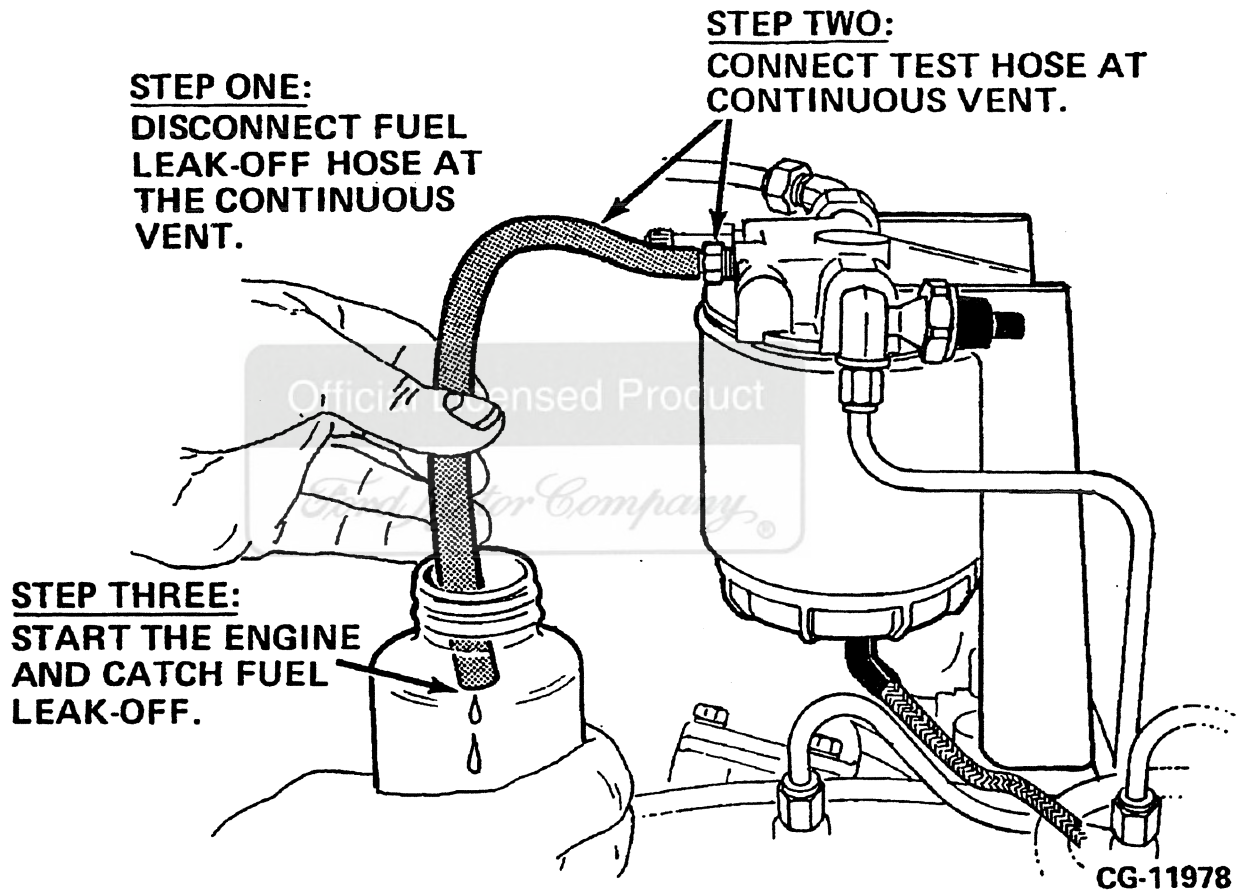


Figure 9.13. Diagnostic Test For Blocked Orifice

#### PROCEDURE: (Refer to Figure 9.14)

Test check valve operation as follows:

1. Using a clean test hose, connect one end to the continuous vent and check valve fitting.
2. Blow into the open end of the hose and see if it holds pressure. You should feel resistance.

#### RESULT/CORRECTIVE ACTION:

- Check valve holds pressure, valve is OK.
- Check valve **DOES NOT** holds pressure, replace vent and check valve assembly.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • DIAGNOSTICS - Continued

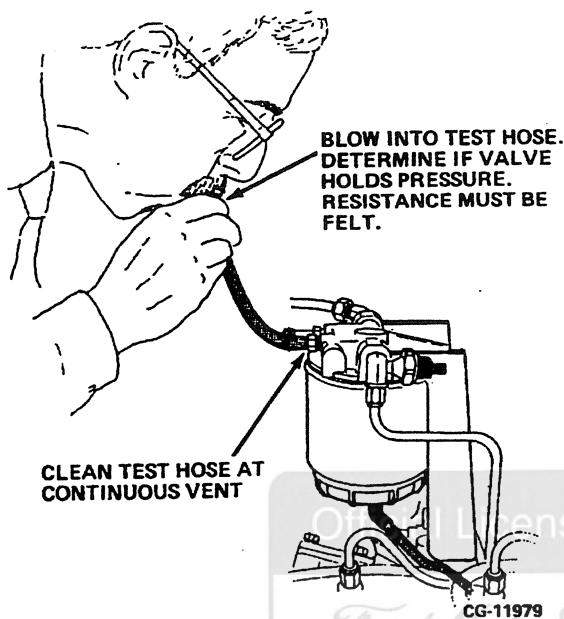


Figure 9.14. Testing Check Valve in  
Continuous Vent  
Fuel Priming Valve Assembly

**NOTE:** This component is used to charge the fuel system during production and bleed the fuel system of air during service.

#### CAUTION



When cranking the engine and depressing the fuel priming valve, catch any fuel released from the priming valve in a container to prevent the possibility of fuel contacting any hot engine component.

**PROBLEM:** External Leakage.

**PROCEDURE:** (Refer to Figure 9.15)

1. Visually inspect for leakage at the header mating surface and at the fuel priming valve under the cap.
2. If leakage is not evident with the cap on, there is no need to remove it.

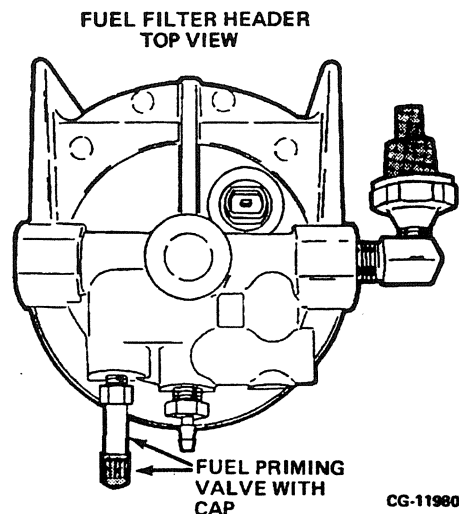


Figure 9.15. Fuel Priming Valve Location  
**RESULT/CORRECTIVE ACTION:**

- If leakage is detected, install a new fuel priming valve assembly.

**Water to Fuel Probe and Water in Fuel Module (WIF)**

**NOTE:** The vehicle is equipped with a water in fuel warning lamp which is dash mounted. The lamp will light when the drain bowl is full indicating the need to drain the water and sediment from the drain bowl

**PROBLEM:** Dash warning lamp stays "ON" (with ignition switch on).

**PROCEDURE:** (Refer to Figure 9.16)

1. Drain the water separator drain bowl, as described under • MAINTENANCE in this section.

**RESULT/CORRECTIVE ACTION:**

- Lamp goes "OFF", the system is operational.
  - Lamp stays "ON", proceed with Step 2.
2. Disconnect the water in fuel probe harness lead at the probe.

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

FUEL FILTER/WATER SEPARATOR ASSEMBLY  
– Continued  
[U-Haul Applications Only]

#### • DIAGNOSTICS – Continued

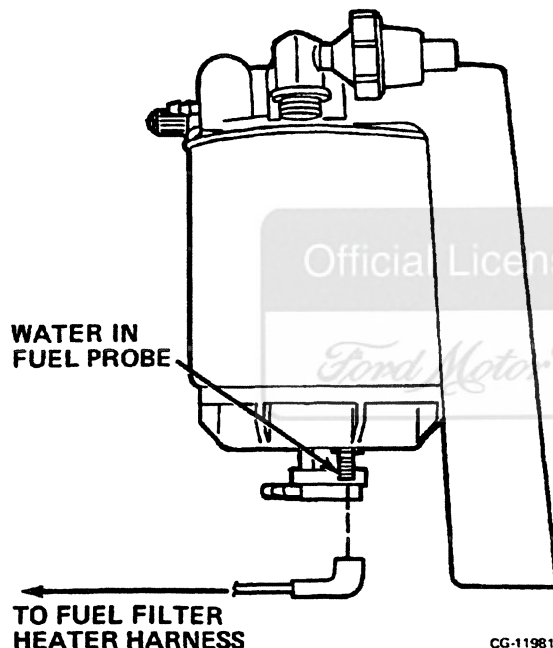


Figure 9.16. Water in Fuel Probe Location  
For Diagnostic Testing

#### RESULT/CORRECTIVE ACTION:

- Lamp goes "OFF", remove the drain bowl from the fuel filter element and replace the water in fuel probe, located in the drain bowl.
- Lamp stays "ON", proceed with Step 3.

#### PROCEDURE:

Disconnect the water in fuel (WIF) module from the cab wiring harness. Refer to CTS-4387 and 1 087 460 R2 for electrical circuit diagrams.

#### RESULT/CORRECTIVE ACTION:

- Lamp goes "OFF", install a new water in fuel module (WIF).
- Lamp stays "ON", look for a ground short in the wiring.

**PROBLEM:** Suspect warning lamp does not light when the specified level of water is attained in the drain bowl.

#### PROCEDURE:

1. Turn the ignition key to the "ON" position and disconnect the water in fuel (WIF) module from the harness plug.

**RESULT/CORRECTIVE ACTION:** (Refer to Figure 9.17A)

- Dash lamp does not light
  - a. Check for current at pin A of the WIF module harness plug socket.
    - If no current is present, check the fuse and circuitry.
    - If current is present, jump between pin sockets A and B with the key switch "ON".
      - If dash lamp lights, replace WIF module.
      - If dash lamp **DOES NOT** light, replace bulb or repair circuit.



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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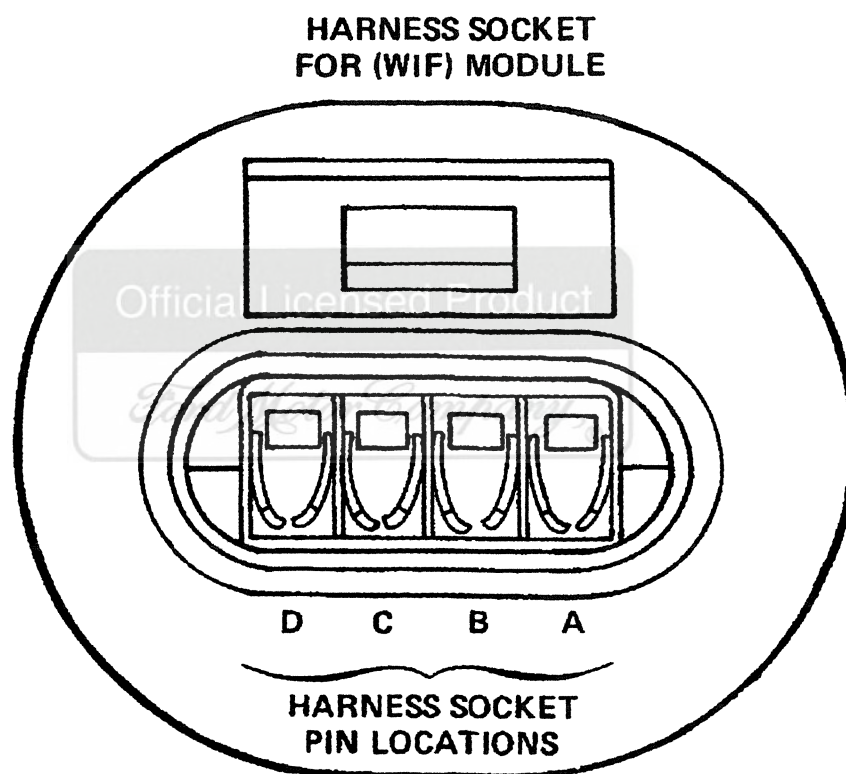
### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • DIAGNOSTICS - Continued

Water in Fuel Probe and Water in Fuel  
Module (WIF) - Continued



<u>TERMINAL IDENTIFICATION</u>		
<u>PIN</u>	<u>DESCRIPTION</u>	<u>CIRCUIT</u>
A	IGNITION RUN	19F
B	WIF LIGHT	19D
C	LAMP TEST	19E
	GROUND	
D	WATER PROBE SENSOR	19C

CG-11986A

Figure 9.17A. Pin Location for WIF Module Engine Harness Socket

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • DIAGNOSTICS - Continued

#### Water in Fuel Probe and Water in Fuel Module (WIF) - Continued

##### • Dash lamp lights

a. Test wire continuity between pin socket D (Figure 9.17A) and the harness connector for the probe (located on the fuel filter heater harness).

- If continuity is **OK**, check the water in fuel probe as follows:
  - Visually inspect for corrosion or erosion of the probe or fuel leakage, which may cause the circuit to **NOT** be completed. Correct leakage or replace the probe as required.
  - Check the probe for continuity as shown in Figure 9.17B. If continuity is **NOT OK**, replace the probe.
- If continuity is **NOT OK** between pin socket D and the probe harness connector:
  - Repair or replace the wire.

#### • MAINTENANCE

Water should be drained from the engine mounted fuel filter/water separator whenever the warning lamp comes on or every 5000 miles (8046 km).

**NOTE:** More frequent drain intervals may be required depending on fuel quality and vehicle usage.

The instrument panel warning lamp (water in fuel) will glow when approximately 0.1 quarts (0.1 liters) of water has accumulated in the drain bowl. When the warning lamp glows, shut off the engine as soon as safely possible and follow the drain procedure.

1. Stop the vehicle and shut off the engine. (Wait 2-5 minutes for the water to settle).

**NOTE:** Failure to shut off the engine prior to draining the water separator will cause fuel leakage.

2. Place a container under the water drain tube (Refer to Figure 9.9)

3. Open the drain valve by turning counterclockwise (as viewed from the bottom) (Refer to Figure 9.18). Drain for about 10 seconds or until clear diesel fuel flows from the drain bowl.

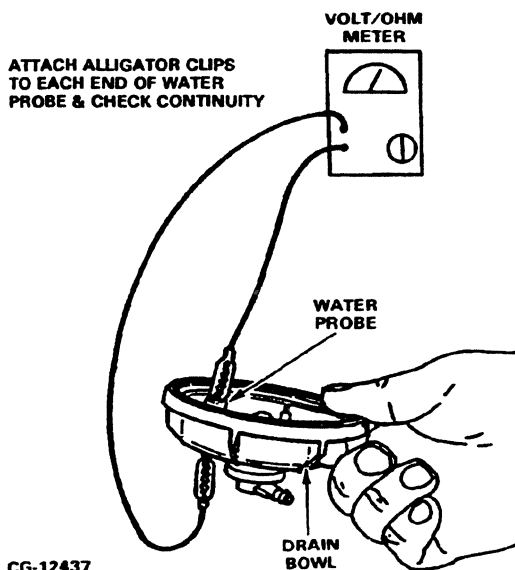


Figure 9.17B. Water Probe Continuity Check

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • MAINTENANCE - Continued

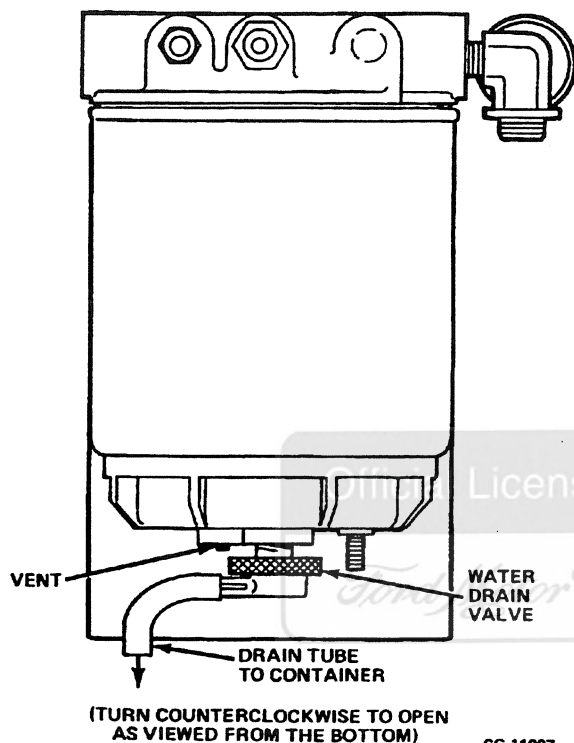


Figure 9.18. Fuel Filter/Water Separator  
Drain Location

4. After the water is completely drained, close the valve by turning clockwise (CW) until the valve is fully seated. Verify draining has stopped. Properly dispose of the drained fluid.

5. Restart the engine and check the water in fuel lamp. The lamp should not glow.

#### • RECONDITIONING

After Diagnostic Inspection

When confronted with the need to either clean or replace component parts of the fuel filter, fuel heater and water separator assembly the following procedures must be followed:

**NOTE:** Complete disassembly is not always required. Disassemble only as far as necessary to replace the worn part(s).

#### • DISASSEMBLY

(Reference Nos. refer to Figure 9.19A)

1. Disconnect all lines, hoses and electrical connections. Remove the filter assembly from the engine.
2. Remove the drain bowl (13) from the fuel filter element (9).
3. Remove drain bowl "O" ring (10) and discard.
4. Unscrew filter element (9) from threaded insert (8). Discard element (9).
5. Remove drain valve cap nut (11) to disengage the drain valve (15). Remove drain valve seal (12) and discard. Remove the drain valve assembly and clean as necessary.
6. Do not remove the vent valve assembly (14). If damaged, replace the entire drain bowl assembly.
7. Unscrew water sensor probe (16) and discard "O" ring (17).
8. Remove the threaded insert (8) which secures the fuel heater (7) to the header (2) using a box end or socket wrench. Clean threads on insert and at header to remove old thread sealant.
9. Remove fuel heater (7) and "O" ring (6) from header. Discard the "O" ring (6).
10. Using a small wrench, remove the following from the header (2):
  - Vacuum switch (1) (fuel filter element replacement indicator).
  - Continuous vent and check valve assembly (4).
  - Fuel priming valve assembly (3).

**NOTE:** Clean threads to remove old thread sealant.

#### • INSPECTION

1. Visually inspect components for wear, thread damage and debris.
2. Clean or replace as required.

#### • CLEANING

1. Wash all components which are to be replaced with clean diesel fuel.
2. Dry thoroughly.

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued

[U-Haul Applications Only]

#### • REASSEMBLY

**NOTE:** Apply a thin coat of clean fuel oil to all "O" rings prior to installation.

1. Install the following components in the header (2) with Loctite Thread Sealant (or equivalent) on the threads:

- Continuous vent (4).
- Vacuum switch (1).
- Fuel priming valve assembly (3).

2. Insert a new "O" ring (6) onto the fuel heater (7). Install the heater into the header (2) with a gentle rocking motion.

**NOTE:** Apply Loctite No. 271 (or equivalent) to the threaded insert and tighten to 50 lbf-ft (68 N-m).

3. Assemble drain bowl components as follows:

- Using a new "O" ring (17), install the water sensor probe and tighten to 18 lbf-in.
- Insert drain valve (15) into drain bowl (13). Carefully install drain valve seal (12), coat the face (top surface) of the drain valve stem with Loctite 242 and secure the drain valve cap nut (11). Tighten the cap nut to 18 lbf-in. **NOTE:** Do not apply Loctite to the cap nut or drain valve threads.

4. Using a new drain bowl "O" ring, assemble the drain bowl assembly to the filter element (9).

**NOTE:** Install a new filter element (9) as described earlier in this section. Prime the filter element by capping the center hole and filling the filter with clean fuel. Plugging the center hole forces fuel to go through the filtering media. Remove the plug and install the primed filter. Refer to Figure 9.19B.

5. Reconnect all lines, hoses and electrical connections.

6. Start the engine and visually inspect for leaks at all sealing surfaces. Correct as required.

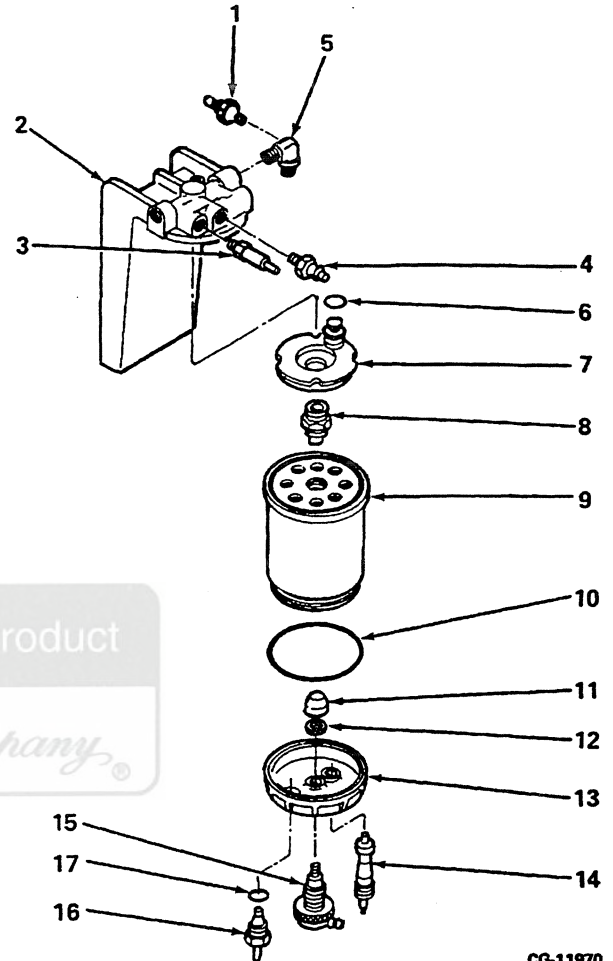


Figure 9.19A. Fuel Filter, Fuel Heater and Water Separator Assembly

- |                          |                    |
|--------------------------|--------------------|
| 1. Vacuum Switch (Fuel   | 11. Cap Nut, Drain |
| Filter Element Re-       | Valve Stem         |
| placement Indicator)     | 12. Seal, Drain    |
| 2. Header/Base Assembly  | Valve              |
| 3. Fuel Priming Valve    | 13. Water Separ-   |
| w/Cap                    | ator Drain Bowl    |
| 4. Continuous Vent       | 14. Vent/Valve     |
| w/Check Valve            | Assembly (Not      |
| 5. Male Elbow            | served             |
| 6. Fuel Heater "O" Ring  | separately)        |
| 7. Fuel Heater           | 15. Drain Valve    |
| 8. Threaded Insert       | 16. Probe, Water   |
| 9. Fuel Filter Element   | Sensor             |
| 10. "O" Ring, Drain Bowl | 17. "O" Ring,      |
|                          | Water Sensor       |

# SERVICE MANUAL

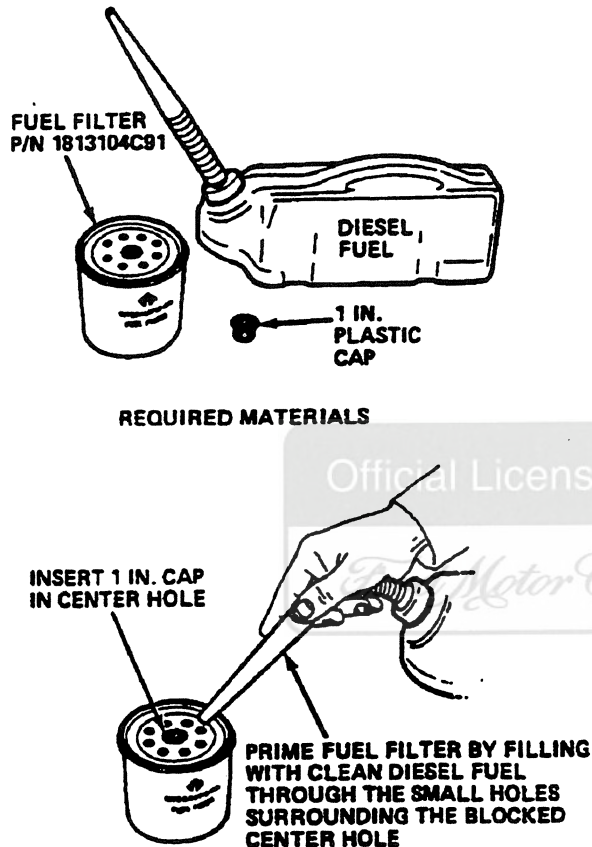
## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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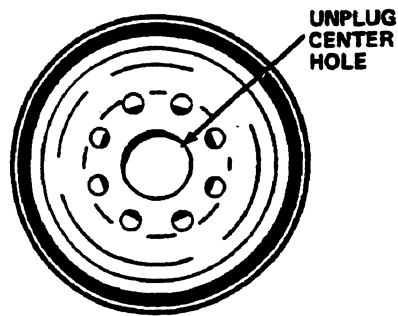
### FUEL FILTER/WATER SEPARATOR ASSEMBLY

- Continued  
[U-Haul Applications Only]

#### • REASSEMBLY - Continued



BLOCK CENTER HOLE AND  
PRIME FUEL FILTER



REMOVE 1 IN. PLUG AND  
INSTALL FILTER ELEMENT

CG-14169

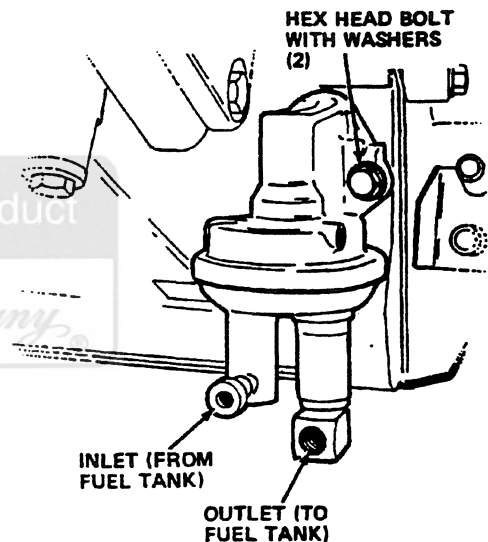
Figure 9.19B. Prime Fuel Filter Element

### FUEL SUPPLY PUMP

(Removal & Reassembly)  
[All Applications]

#### ■ Removal

1. Disconnect hose from the fuel supply pump inlet and inverted flare tube connecting nut from the fuel outlet. Refer to **Figure 9.20**.
2. Loosen and remove the two bolts with washers (**Figure 9.20**) which fasten the fuel supply pump to the crankcase.



CG-11172

Figure 9.20. Fuel Supply Pump Removal

3. Remove fuel supply pump. Be careful not to force or damage fuel supply pump arm upon removal. Remove gasket and discard.

#### ■ Cleaning

1. Clean the fuel supply pump assembly in clean diesel fuel. Dry with filtered air.
2. Clean all gasket material from the pump and crankcase mounting pad.

#### ■ Inspection

1. Visually inspect the fuel supply pump arm. Replace the pump if arm is bent or damaged.



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL SUPPLY PUMP (Removal & Reassembly) [All Applications]

##### ■ Reassembly

1. Install the fuel supply pump as follows:

**IMPORTANT**  
**FUEL SUPPLY PUMP INSTALLATION**  
**REQUIRES SPECIAL ATTENTION TO**  
**AVOID BREAKAGE OF THE PUMP**  
**ARM DURING INSTALLATION.**

- a. Position engine approximately 90° ATDC (timing mark on vibration damper toward top). At this position, the fuel supply pump cam lobe will be away from the pump arm pathway. (Refer to Figure 9.21.)
- b. Using a new gasket, attempt to install the pump. If pump flange can be aligned, **WITHOUT RESISTANCE**, complete installation. If **RESISTANCE IS MET**, rotate engine through 360° to the next stroke and proceed with pump installation. (Refer to Figure 9.22.)
- c. Tighten mounting bolts with washers to standard torque.
- d. Install fuel outlet and inlet line.
- e. Inspect all fuel supply pump line connections for fuel leakage and oil leakage at the pump mounting pad.

**IMPORTANT**  
**FACTORY INSTALLATION OF THE**  
**FUEL PUMP CAM ONTO THE CAM-**  
**SHAFT ASSURES PROPER CAM LOBE**  
**POSITION WHEN ENGINE NUMBER**  
**ONE CYLINDER IS APPROXIMATELY**  
**90° ATDC COMPRESSION STROKE.**  
**FIELD SERVICE TECHNICIANS MUST**  
**FOLLOW THE FUEL PUMP CAM IN-**  
**STALLATION PROCEDURE IN SECTION**  
**4.**

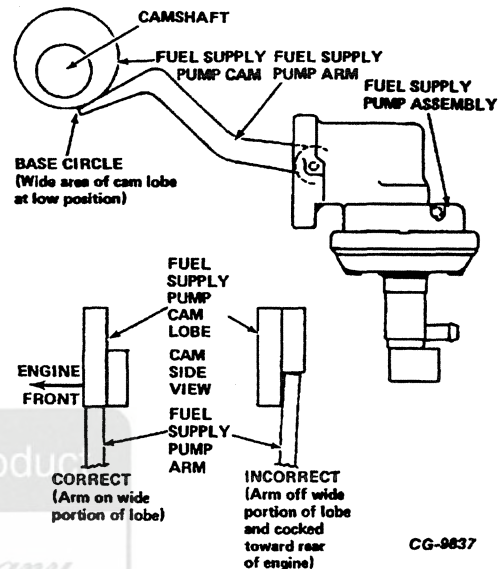


Figure 9-21. Fuel Supply Pump and Camshaft Relationship

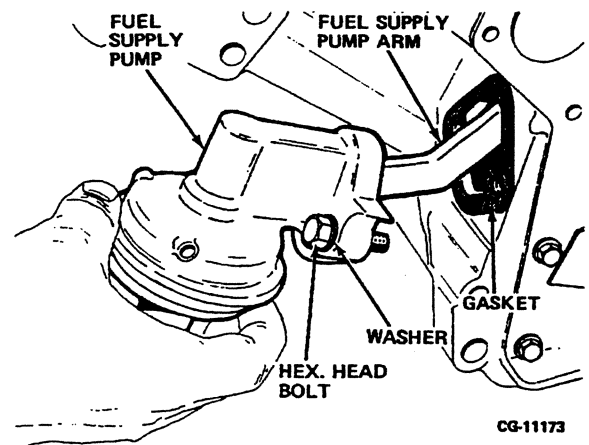


Figure 9.22. Installing Fuel Supply Pump

# SERVICE MANUAL

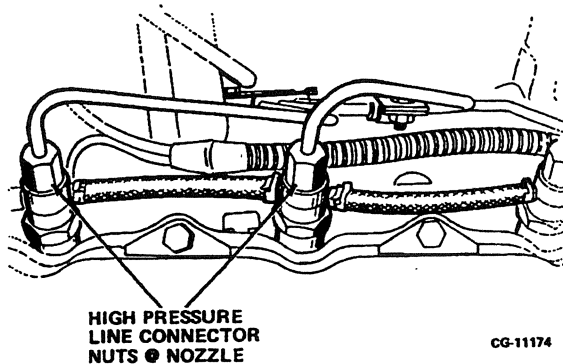
## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION PUMP (Removal & Reassembly) [All Applications]

#### ■ Removal

1. Loosen all 8 fuel injection line connecting nuts at nozzles using an open end wrench. Refer to **Figure 9.23**.

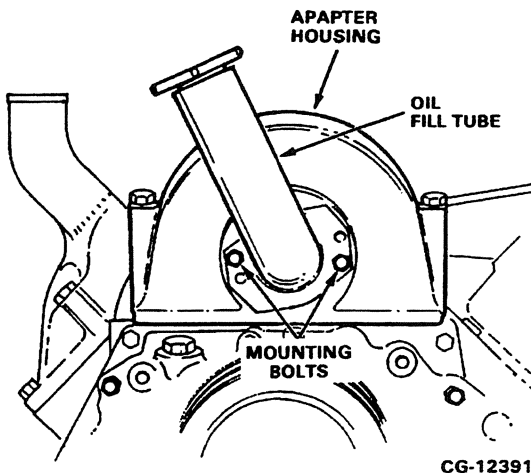


**Figure 9.23. Removing Fuel Inlet (High Pressure) Lines at Nozzle**

**NOTE:** It is not necessary to remove injection lines from injection pump to remove injection pump. If lines are to be removed, loosen injection line fittings at injection pump before removing it from engine.

2. Remove the adapter housing oil fill tube or cover plate, **Figure 9.24**, to access the injection pump drive gear mounting bolts.

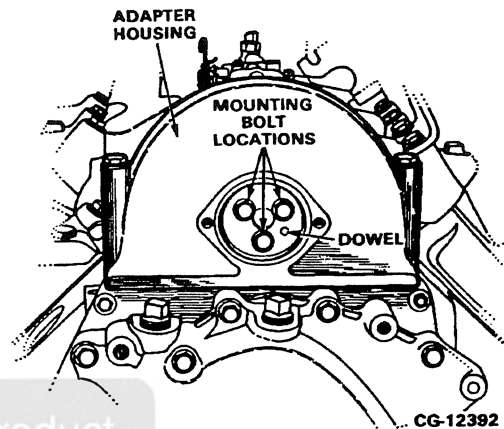
**NOTE:** The oil fill tube is sealed with R.T.V. sealant. There is no gasket.



**Figure 9.24. Oil Fill Elbow Removal  
[1988 MY and prior shown, 1989 MY and  
beyond use a Cover Plate]**

**NOTE:** Cover plate is sealed with R.T.V. sealant. There is NO gasket.

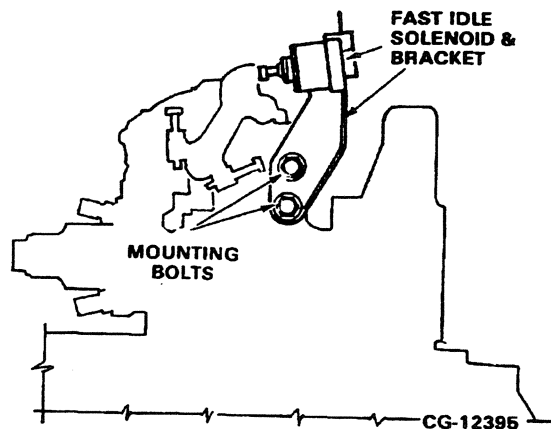
3. Remove injection pump drive gear mounting bolts (**Figure 9.25**) using a 5/16" 12 pt. socket.



**Figure 9.25. Injection Pump Drive Gear Mounting Bolt Removal**

4. Disconnect the electrical connectors at the injection pump.

5. Remove the fast idle solenoid bracket assembly (**Figure 9.26**) to provide access to the injection pump mounting nuts.



**Figure 9.26. Fast Idle Solenoid Bracket Removal**

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION PUMP (Removal & Reassembly) [All Applications]

##### ■ Removal – Continued

6. Remove the fuel return hose and clip from the 90° elbow at the governor cover. Cap opening at the governor cover elbow. Refer to Figure 9.27.

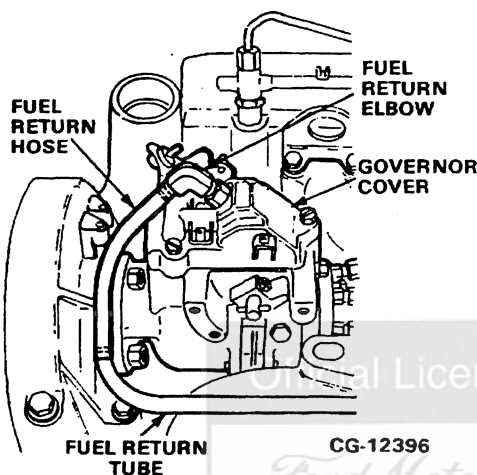


Figure 9.27. Removing Fuel Return Line

7. Remove the filter to injection pump tube (17 Figure 9.7) as described in this section under "Fuel Filter Assembly – Removal". Cap the pump opening.

8. Using injection pump wrench ZTSE-4132, remove injection pump mounting nuts and washers to adapter housing as shown in Figure 9.28.

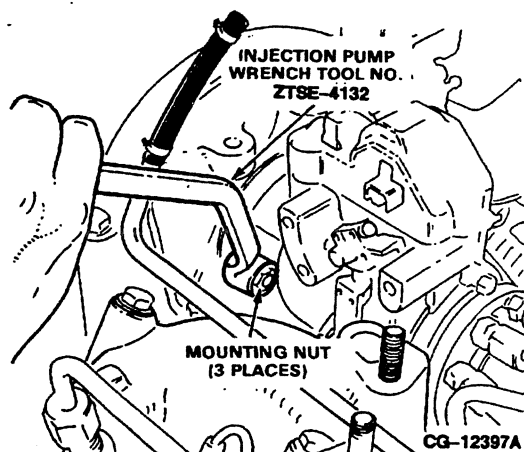


Figure 9.28. Injection Pump Mounting Nut Removal

9. Lift injection pump with high pressure lines from the mounting studs on the adapter housing. Refer to Figure 9.29. Install protective caps on the high pressure lines and nozzles.

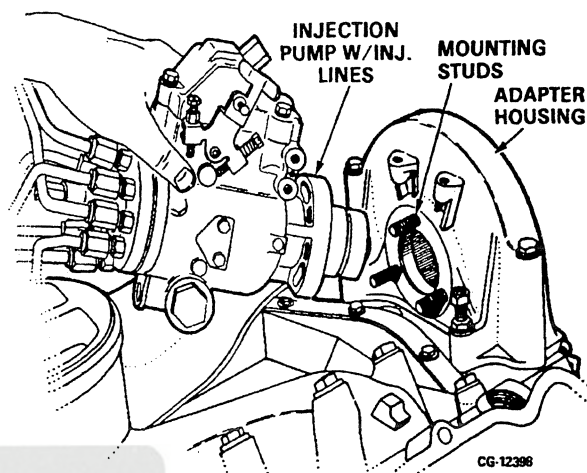


Figure 9.29. Injection Pump Removal

**NOTE:** If injection pump is to be replaced, remove injection lines at pump, with pump and lines removed as an assembly, using fuel line wrench ZTSE-4133. Cap all fittings using the protective cap set ZTSE-4135. Install fuel lines to the injection pump prior to installing the injection pump on the engine.

#### Removing Injection Pump Gear [All Applications]

##### ■ Injection Pump and Camshaft Gears

Injection pump and camshaft gears have a "Y" stamped on the face of the gears for alignment. In addition to the "Y", the gear teeth adjacent to the "Y" on the camshaft gear are permanently dyed.

**NOTE:** The "Y" marks are not easily visible with the front cover on the engine. For ease of assembly, draw a reference line up from the "Y" mark on the gear, prior to removing the gear.

**NOTE:** The following is necessary only if the injection pump drive gear is replaced.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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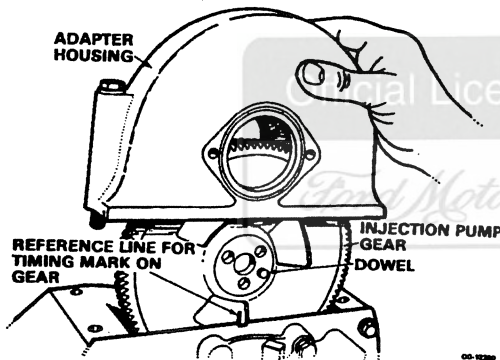
### FUEL INJECTION PUMP (Removal & Reassembly) [All Applications]

#### ■ Removal – Continued

#### Removing Injection Pump Gear – Continued

10. Remove the injection pump adapter housing bolts and adapter housing (Figure 9.30).

**IMPORTANT**  
**DO NOT REMOVE INJECTION PUMP**  
**DRIVE GEAR YET.**



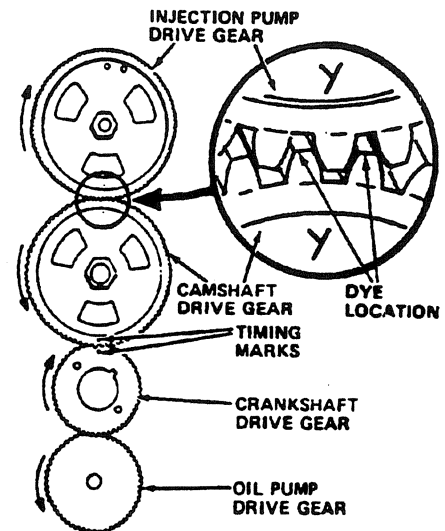
**Figure 9.30. Removing Adapter Housing and Marking Injection Pump Gear**

11. Bar the engine over to TDC compression stroke for No. 1 cylinder.

**NOTE:** Remove glow plugs to facilitate turning engine over by hand.

12. To verify that No.1 piston is at TDC position, remove the right valve cover and observe the No. 1 cylinder valve lever. The injection pump drive gear dowel must be at four o'clock position. The scribe line on the vibration damper should be at TDC.

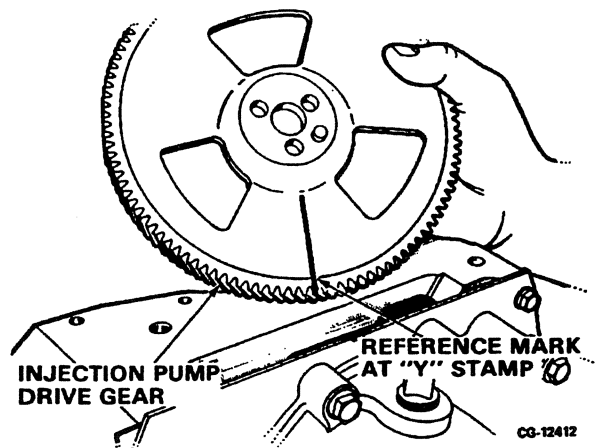
**NOTE:** With engines at TDC compression for No. 1 cylinder, gears should have the stamped "Y"'s aligned. Refer to Figure 9.31.



**Figure 9.31. Timing Mark Aligned**

13. Slide the injection pump gear back (do not remove) to expose the top of the camshaft gear when looking down into the top of the front cover. Draw a reference line up from the "Y" mark on the injection pump gear prior to removing the gear. **DO NOT REMOVE THE INJECTION PUMP GEAR WITHOUT FOLLOWING THIS PROCEDURE.**

14. Remove the injection pump drive gear, Figure 9.32.



**Figure 9.32. Removal of Injection Pump Gear**



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION PUMP (Removal & Reassembly) [All Applications]

##### ■ Reassembly

#### Injection Pump Gear Installation (With Front Cover Installed)

**IMPORTANT**  
PRIOR TO REASSEMBLY BE SURE ALL  
MATING SURFACES ARE CLEAN AND  
FREE OF EITHER GASKET MATERIAL  
OR R.T.V. SEALANT.

1. Install injection pump drive gear as follows:

**NOTE:** If a new gear is being installed, mark the new gear in reference to the "Y" mark stamped on the front of the gear. (Refer to Figure 9.32.)

- a. Install the injection pump drive gear to the camshaft gear with the reference line at six o'clock.
- b. Be sure the "Y" mark reference line on the injection pump drive gear mates in between the two dyed gear teeth of the camshaft gear. Refer to Figure 9.31.

**IMPORTANT**  
VERIFY THAT NO. 1 PISTON IS AT  
TDC PRIOR TO INSTALLING THE  
INJECTION PUMP DRIVE GEAR.

2. Apply a 1/8" dia. bead of R.T.V. sealant into the narrow groove at the bottom and sides of the gear tower; and a 3/16" dia. bead across the front of the gear tower. Refer to Figure 9.33.

**IMPORTANT**  
ASSEMBLE COMPONENTS WITHIN 15  
MINUTES OF R.T.V. APPLICATION. IF  
SEALANT "SETS UP" IT LOSES ITS  
SEALING EFFECTIVENESS.

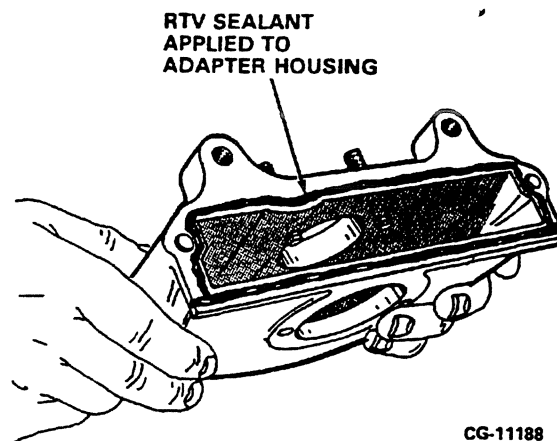


Figure 9.33. R.T.V. Application to  
Adapter Housing

3. Install the adapter housing over the injection pump drive gear and tighten the four mounting bolts. Refer to Figure 9.34.

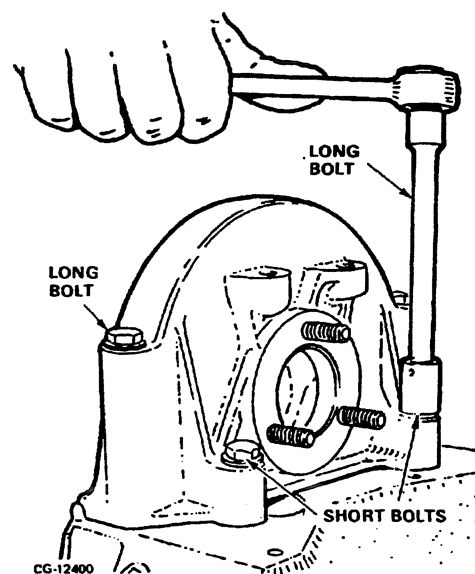


Figure 9.34. Adapter Housing Installation

**NOTE:** With the injection pump adapter housing mounted to the engine, the injection drive gear drive cannot "jump" timing.



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION PUMP (Removal & Reassembly) [All Applications]

#### ■ Injection Pump Installation

1. Prepare injection pump for mounting to engine by rotating injection pump drive shaft so slot in drive shaft is approximately at 4 o'clock (viewed from front of engine).

2. Mount the injection pump assembly on the adapter housing over the three mounting studs and align the dowel on the injection pump drive gear with the slot in the drive shaft.

**NOTE:** Do not slide the injection pump all the way forward on the studs. Slide about halfway to allow clearance for nut installation on studs at the injection pump mounting flange.

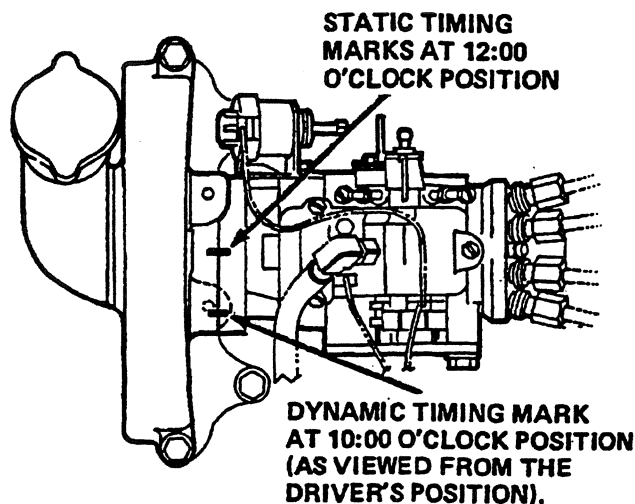
3. Align the scribed line on the pump with the scribed line on the adapter housing (at the 10:00 position) after the mounting nuts are started on the adapter housing studs. Refer to Figure 9.35.

#### IMPORTANT

NEW ENGINE AND INJECTION PUMP TIMING IS SET IN TWO STEPS DURING THE PRODUCTION PROCESS.

**STEP ONE:** INITIAL OR STATIC TIMING IS MARKED AT THE 12:00 POSITION ON THE PUMP FLANGE AND ADAPTER HOUSING. THESE MARKS ARE ONLY USED AS AN APPROXIMATE TIMING SETTING PRIOR TO STEP TWO, DYNAMICALLY TIMING THE ENGINE.

**STEP TWO:** FINAL TIMING IS DONE DYNAMICALLY. IF TIMING ADJUSTMENT IS REQUIRED, A ROBOTIC DEVICE AUTOMATICALLY ADJUSTS THE INJECTION PUMP POSITION BY ROTATING IT SLIGHTLY (ADVANCE OR RETARD), AND STRIKING NEW MARKS AT THE 10:00 POSITION. THE 12:00 MARKS MAY BE OUT OF ALIGNMENT DUE TO THE AUTOMATIC ROTATION OF THE PUMP DURING THE DYNAMIC TIMING ADJUSTMENT. ONLY THE 10:00 MARKS MUST BE IN ALIGNMENT.



**NOTE:** DYNAMIC TIMING MARKS @ 10:00 O'CLOCK MUST BE ALIGNED. STATIC TIMING MARKS @ 12:00 O'CLOCK MAY BE MISALIGNED AS LONG AS THE 10:00 O'CLOCK MARKS ARE ALIGNED. LATER PRODUCTION ENGINES HAVE THE 12:00 O'CLOCK MARK ON THE PUMP FLANGE REMOVED. SERVICE PUMPS WILL CONTINUE TO HAVE A 12:00 O'CLOCK MARK AS A REFERENCE/STARTING POINT.

CG-14304

Figure 9.35. Mounting Injection Pump

## SERVICE MANUAL

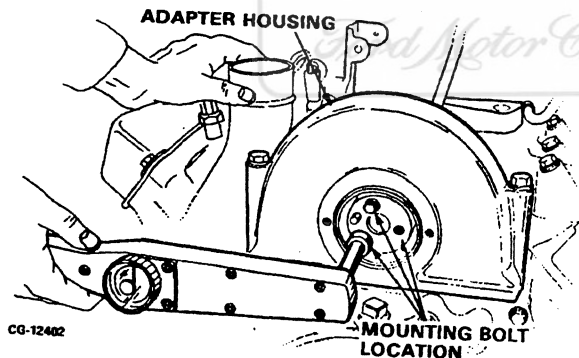
### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION PUMP ( Removal & Reassembly) [All Applications]

#### ■ Injection Pump Installation - Continued

**NOTE:** If service requires injection pump replacement, use the 12:00 scribe marks as a reference, then dynamically time the pump using the Tach-N'-Time™ Instrument (ZTSE-4142) and scribe new alignment at the 10:00 position. Refer to CGES-460 "7.3 L Diesel Engine Diagnostic Manual".

4. Install the three injection pump gear mounting bolts and tighten to specified torque (see Specifications). Refer to Figure 9.36.



**Figure 9.36. Tightening Injection Pump  
Gear Mounting Bolts**

5. Tighten injection pump mounting nuts using injection pump wrench ZTSE-4132. Refer to Figure 9.28.

6. Install the oil fill tube and apply R.T.V. at the mounting surface prior to installation.

7. Remove all protective caps and install the fuel return hose, filter to pump supply tube and fuel injection line to nozzles. Tighten to **SPECIFIED TORQUES** (see **SPECIFICATIONS**).

#### IMPORTANT

USE NEW RUBBER SEALING SLEEVES ON ALL FUEL LINE CONNECTORS, EXCEPT HIGH PRESSURE NOZZLE LINES WHICH HAVE SWEDGED FITTINGS.

#### IMPORTANT

FOR DETAILED INSTRUCTIONS ON CLEANING, INSPECTING AND SERVICING THE FUEL INJECTION PUMP, REFER TO CGES-475 "THE STANADYNE DB-2 FUEL INJECTION PUMP SERVICE MANUAL.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Troubleshooting

1. Where good combustion, specified engine temperature control and clean fuel prevail, nozzles require little attention.

Nozzle trouble is usually indicated by combustion knock.

2. While combustion knock may be caused by defective nozzles, it may also be caused by other engine related problems such as:

- Air in fuel
- Incorrect fuel
- Water in fuel
- Dirty or damaged fuel filter
- Incorrect maximum fuel setting
- Faulty injection pump
- Insufficient engine lubrication
- Incorrect pump timing
- Faulty engine valves

3. Where faulty nozzle operation is suspected on an engine that is knocking, a simple test can be made to determine which cylinder is causing the difficulty.

4. With the engine running at a speed that makes the defect most pronounced, momentarily loosen the high pressure fuel inlet connection on one nozzle assembly sufficiently to "cut out" the cylinder.

**NOTE:** When loosening the fuel inlet connection to test nozzle operation, the next cylinder in the firing order may miss. This is due to the creation of a low pressure area in the distributor rotor located in the hydraulic head of the 7.3 L fuel injection pump. The condition will correct itself after a few cycles.

5. Check each cylinder in the same manner. If one is found where loosening causes knocking to cease, the injection nozzle for that cylinder should be tested.

6. Nozzle testing, disassembly, cleaning and reconditioning must be done only by an authorized International® dealer or other diesel service outlet equipped and qualified to perform such services.

**NOTE:** When servicing injection nozzle assemblies, the necessity of cleanliness cannot be over-emphasized. A clean workbench, clean washing fluid containers, clean tools and clean hands are all essential to produce satisfactory results. The use of suitable tools for this type of work is equally important.

#### IMPORTANT

**PRIOR TO SERVICING FUEL INJECTION NOZZLE AND HOLDER ASSEMBLIES, FOLLOW THE REMOVAL PROCEDURE AND CONNECT THE ASSEMBLED NOZZLE AND HOLDER ASSEMBLY TO NOZZLE TESTER ZTSE-4045-A AND PERFORM TESTS UNDER "INJECTION NOZZLE TESTING", IN THIS SECTION.**

This information will indicate the degree of repair the nozzle and holder assembly will require, help diagnose any problems that might be present, and in some cases, avoid unnecessary labor and expense in servicing the nozzle holder assembly.

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION NOZZLES

#### ■ Troubleshooting – Continued

### TROUBLESHOOTING GUIDE

FAULT	POSSIBLE CAUSE	REMEDY
Nozzle Bluing.	<ol style="list-style-type: none"> <li>1. Faulty installation or tightening.</li> <li>2. Insufficient cooling.</li> </ol>	<p>Replace nozzle.</p> <p>Correct cooling system.</p>
Nozzle opening pressure too high.	<ol style="list-style-type: none"> <li>1. Incorrect shim adjustment.</li> <li>2. Nozzle valve dirty or sticky.</li> <li>3. Seized nozzle.</li> </ol>	<p>Readjust nozzle shims.</p> <p>Clean nozzle.</p> <p>Replace nozzle tip assembly.</p>
Nozzle opening pressure too low.	<ol style="list-style-type: none"> <li>1. Shim/spacer wear.</li> <li>2. Nozzle valve spring weak or broken.</li> <li>3. Nozzle seat worn.</li> </ol>	<p>Replace worn components and reset VOP.</p>
Nozzle valve seat leakage.	<ol style="list-style-type: none"> <li>1. Nozzle leaks because of excessive carbon deposit or sticking nozzle valve.</li> <li>2. Defective nozzle.</li> </ol>	<p>Clean nozzle.</p> <p>Replace nozzle tip assembly.</p>

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Removal

Before removing nozzle assemblies, clean exterior of each nozzle assembly and the surrounding area with clean fuel oil or solvent to prevent entry of dirt into engine when nozzle assemblies are removed. Also, clean fuel inlet and fuel leak-off piping connections. Blow dry with compressed air.

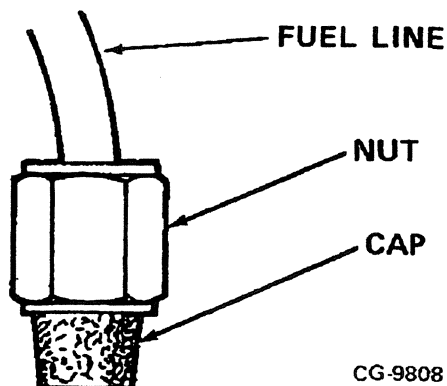
1. Disconnect the high pressure fuel injection line connector nuts at each nozzle.

**NOTE:** Remove and cap the line sensor on No. 4 cylinder nozzle to allow fuel return tee removal.

2. Remove the fuel return (leak-off) lines, as an assembly, as follows. Refer to Figure 9.3.

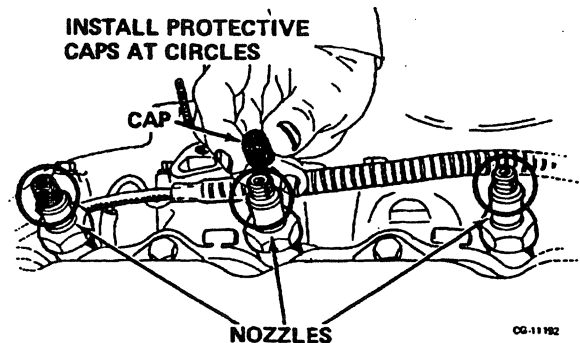
- a. Remove the pump to fuel return tube hose (33) at the fuel elbow (22) at pump. Cap elbow at pump. Disconnect hose from leak-off tee to fuel filter at the leak-off tee.
- b. Loosen the two fuel return tubes (23) and retaining clamps (21) (one at the intake manifold and one at the engine lifting eye).
- c. With clamps removed, remove the return lines and tees as an assembly by lifting tees off the nozzles.

3. Install protective caps from ZTSE-4135 onto the high pressure lines which were disconnected. Refer to Figure 9.37.



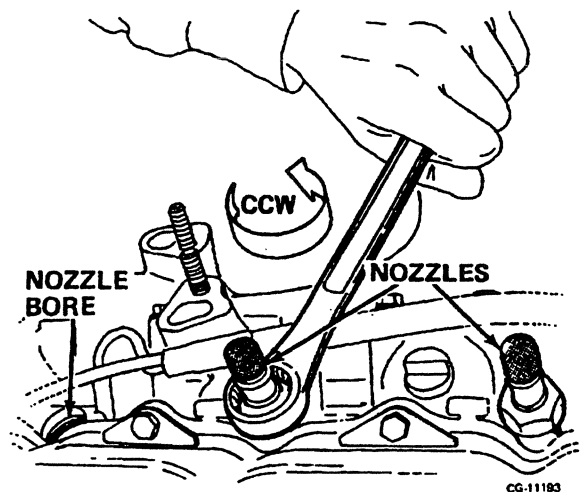
**Figure 9.37. Protective Cap from ZTSE-4135  
on High Pressure Fuel Lines**

4. Install protective caps onto nozzles using ZTSE-4135 protective cap set. Refer to Figure 9.38.



**Figure 9.38. Installing Protective Caps on  
Nozzles**

5. Remove the nozzle from the cylinder head bore using a box wrench. Refer to Figure 9.39. **TURN COUNTERCLOCKWISE TO REMOVE NOZZLES.**



**Figure 9.39. Nozzle Removal**



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION NOZZLES

##### ■ Removal – Continued

6. As nozzles are removed, place a protective cap on the nozzle tip. Place nozzle assemblies in a holding rack (ZTSE-4141). Identify each nozzle as to the cylinder from which it was removed. This permits replacing the nozzles in their respective ports during installation. Refer to Figure 9.40.

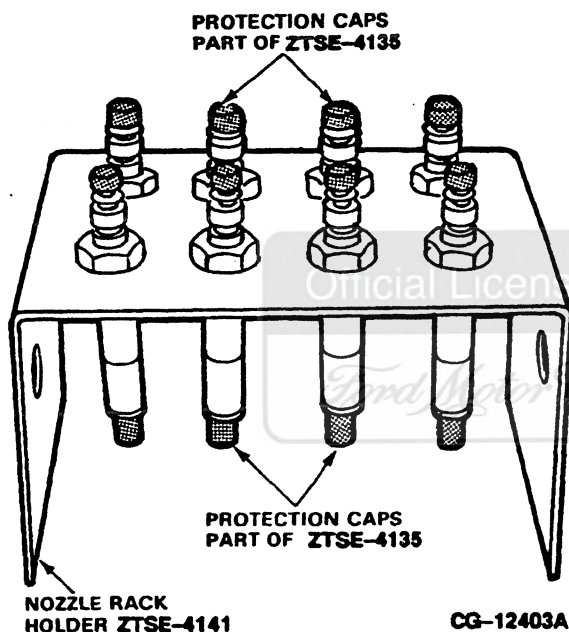


Figure 9.40. Nozzle Holder Rack



#### CAUTION

Be extremely careful not to damage nozzle tips during removal.

#### IMPORTANT

IF COPPER GASKET IS NOT REMOVED WITH THE NOZZLE, USE A PIC TO REMOVE THE SEAL WASHER FROM THE NOZZLE BORE. DISCARD EACH SEAL WASHER AND REPLACE WITH NEW UPON REASSEMBLY. REFER TO FIGURE 9.41.

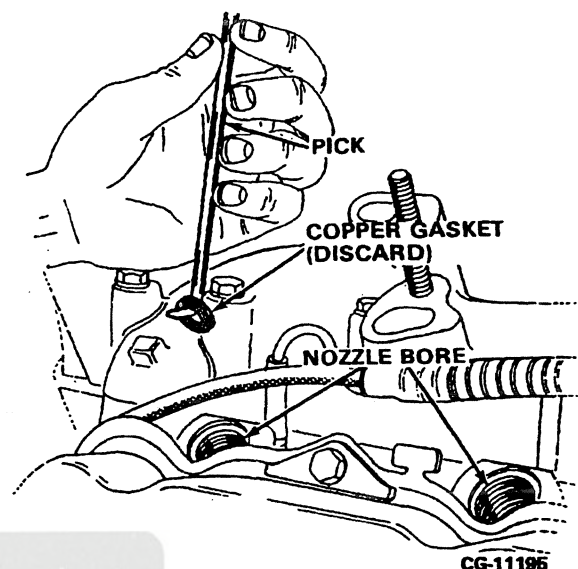


Figure 9.41. Copper Gasket Removal

##### ■ Cleaning (Nozzle Bore in Cylinder Head)

1. Thoroughly clean nozzle bore in cylinder head using nozzle seat cleaner, ZTSE-4139, before re-inserting nozzle holder assembly. Pay particular attention to seating surfaces, in order that no small particles of carbon will cause assembly to be cocked or permit blow-by of combustion gases.

2. Clean injection nozzle seats in cylinder head (Figure 9.42) using nozzle seat cleaner ZTSE-4139 as follows:

- Insert the threaded sleeve of the nozzle seat cleaner, into the nozzle bore of the cylinder head as shown in Figure 9.42.
- Use a 9/16 in. socket to turn the nozzle seat cleaner and remove any carbon build-up from the seat. Blow out with filtered compressed air.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Cleaning (Nozzle Bore in Cylinder Head) – Continued

3. With nozzle bore cleaned, cover cylinder head bores with protective caps from ZTSE-4135 until nozzles are reinstalled.

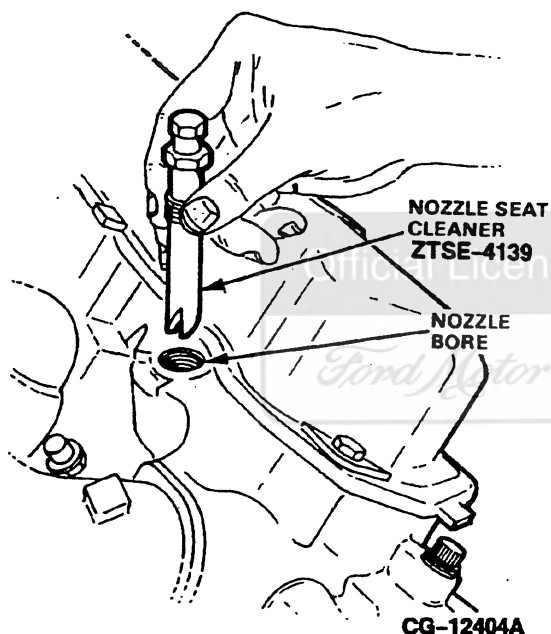


Figure 9.42. Cleaning Nozzle Seats with ZTSE-4139

#### ■ Injection Nozzle Testing

**IMPORTANT**  
**IT IS ADVISABLE TO TEST NOZZLES BEFORE CLEANING THEM.**

1. Prior to nozzle and holder disassembly, the undisturbed assembly should be connected to a hand test pump ZTSE-4045-A (Figure 9.43) and checked for opening pressure and tip leakage.

\*Calibration fluid meets SAE J967 (latest revision) and ISO 4113 standards.

#### IMPORTANT

**READ THE INSTRUCTIONS WHICH ACCOMPANY NOZZLE TESTER ZTSE-4045-A PRIOR TO TESTING THE FUEL INJECTION NOZZLES. FOLLOW THOSE OPERATING INSTRUCTIONS.**

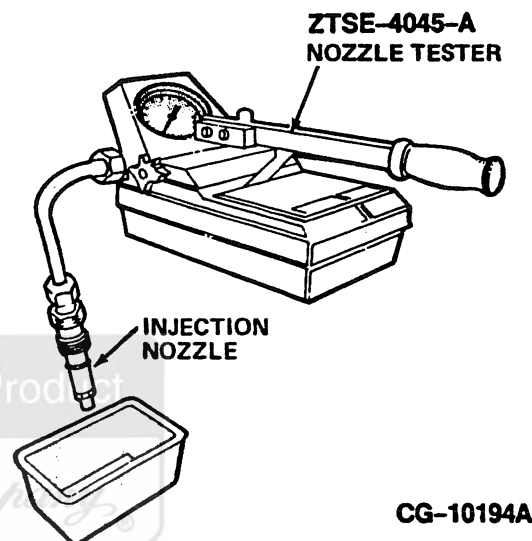


Figure 9.43. Nozzle Assembly Mounted in Test Pump ZTSE-4045-A

#### Prepare test pump for making tests.

- a. Fill the nozzle tester with Viscor 1487C\* calibration fluid. Operate pump handle to expel air from pump and outlet pipe. Operate pump until solid fluid (without air bubbles) flows from end of outlet pipe.
- b. Connect injection nozzle to test pump, as shown in Figure 9.43. Avoid "cross threading". The connector nut must be tightened securely with an open end wrench.

**NOTE:** Any leakage at the connector nut will invalidate injection nozzle testing. Do not confuse leakage at the connector nut with return fuel leak-off.

- c. Bleed air from nozzle. Operate pump for several quick strokes to expel (bleed) air from injection nozzle. Fluid should discharge from the hole in the nozzle tip.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

### FUEL INJECTION NOZZLES

#### ■ Injection Nozzle Testing – Continued

#### CAUTION



KEEP HANDS AWAY FROM NOZZLE DISCHARGE. FLUID DISCHARGING FROM THE NOZZLE UNDER HIGH PRESSURE CAN PENETRATE THE SKIN AND CAUSE INFECTION. MEDICAL ATTENTION SHOULD BE PROVIDED IMMEDIATELY IN THE EVENT OF SKIN PENETRATION.

#### IMPORTANT

EXTENSIVE TESTING BY NAVISTAR INTERNATIONAL TRANSPORTATION CORP. HAS CONCLUDED: 1) PINTLE TYPE NOZZLES USED ON THE 7.3 L DO NOT REQUIRE SPRAY PATTERN ANALYSIS. 2) "CHATTER" OR LACK OF "CHATTER" IS NOT A CAUSE FOR ACCEPTANCE OR REJECTION OF A PINTLE TYPE NOZZLE. 3) RETURN FUEL LEAKAGE CHECK IS NOT REQUIRED. 4) PROPER USE OF THE NOZZLE TESTER ZTSE-4045-A IS CRITICAL WHEN TESTING NOZZLE OPENING PRESSURE AND TIP LEAKAGE. 5) AS A BASIC GUIDELINE, IF THE ENGINE PERFORMANCE CONCERN DOES NOT EXHIBIT AN ENGINE COMBUSTION KNOCK, NOZZLE TESTING IS NOT REQUIRED.

#### TEST 1

#### ■ CHECK NOZZLE OPENING PRESSURE.

Operate the pump handle in slow even strokes to bring the system pressure up. Note the highest pressure reached prior to the nozzle opening. Repeat operation, increasing handle speed if necessary, to establish consistent readings. **NOTE:** Discharge may appear as solid fuel during this test.

Minimum permissible opening pressure for a used nozzle is:

Minimum Permissible VOP  
(Used Nozzle)  
1425 psi (9825 kPa)

**NOTE:** Disregard tip leakage during this test and remember testing of spray pattern is no longer required.

**NOTE:** New nozzles are set at the factory to the following pressure:

Factory Setting VOP  
 $1875 \pm 75$  psi  
(12,928  $\pm$  517 kPa)

After a short period of service, the 7.3 L nozzle will exhibit an opening pressure less than the factory setting.

#### IMPORTANT

REFER TO THE MINIMUM PERMISSIBLE OPENING PRESSURE WHEN EVALUATING NOZZLES.

#### TEST 2

- CHECK FOR TIP LEAKAGE. Blow nozzle tip dry using filtered compressed air. Operate test pump to maintain pressure at about 200 psi (1378 kPa) below the opening pressure obtained in Test 1. Wetting of the nozzle tip is acceptable as long as a drop does not fall within 5 seconds. (Refer to Figure 9.44).

**NOTE:** Make sure that any fluid accumulation at the nozzle tip is not due to fuel leaking down the outside of the nozzle body from the return openings. If questionable, wrap a shop cloth around the nozzle body to prevent fluid leaking down the outside of the nozzle body from reaching the tip.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Injection Nozzle Testing - Continued

#### CAUTION



DO NOT WIPE NOZZLE TIP WITH FINGERS AS INJURY COULD OCCUR AS A RESULT OF HIGH PRESSURE FUEL BEING RELEASED IF THE PINTLE VALVE IS MOVED INWARD. FUEL COULD PENETRATE THE SKIN CAUSING INJURY.

#### IMPORTANT

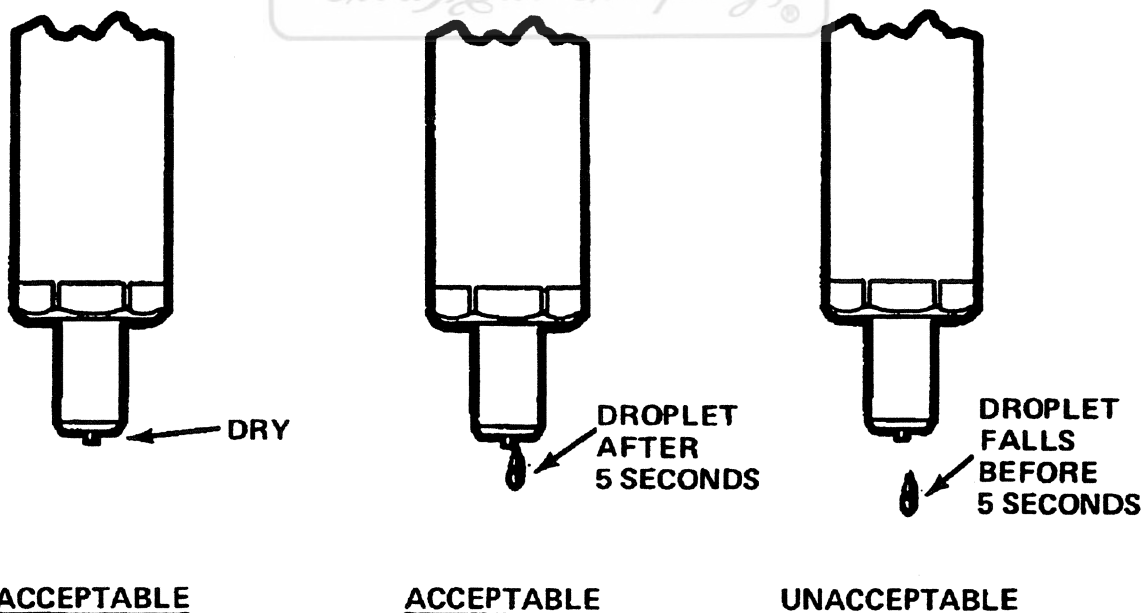
IF NOZZLE PASSES THE NOZZLE OPENING PRESSURE AND TIP LEAKAGE TESTS, IT IS SUITABLE FOR FURTHER SERVICE IN THE ENGINE.

NOZZLES SHOWING LEAKAGE AT NOZZLE TIP SPRAY HOLE OR OPENING PRESSURE BLOW THE MINIMUM PERMISSIBLE LIMIT, ARE DEFECTIVE AND MUST BE REPLACED OR SERVICED (DISASSEMBLED, CLEANED, INSPECTED AND REBUILT).

NOTE: Warranty claims for replacement of the nozzle(s) will not be accepted unless the completed Engine Performance Analysis Guide (CGED-440) is submitted with the returned part(s).

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*Ford Motor Company*



CG-10713

Figure 9.44. Acceptable vs. Unacceptable Nozzle Tip Leakage



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION NOZZLES

##### ■ Disassembly

**NOTE:** Disassemble only those nozzle holder assemblies that fail to meet specifications.

#### CAUTION



WHEN MORE THAN ONE FUEL INJECTION NOZZLE HOLDER IS DISASSEMBLED, KEEP PARTS OF EACH SEPARATE. THE NOZZLE VALVE AND NOZZLE VALVE BODY ARE MATED PARTS, AND MUST BE KEPT TOGETHER; IF REPLACEMENT OF EITHER PART IS NECESSARY, A NOZZLE TIP ASSEMBLY MUST BE ORDERED. NEVER INTERCHANGE THE NOZZLE VALVES AND NOZZLE VALVE BODIES.

Disassemble the nozzle holder assembly for cleaning, inspection and service as follows:

1. Wash all external dirt, grease and carbon deposits from holder assembly with suitable cleaning agent.
2. Remove copper seal washer from nozzle, if not removed earlier. (Discard old copper seal washer.)
3. A brass wire hand brush should be used to remove hardened deposits of dirt or carbon.

#### IMPORTANT

**SOAK NOZZLE HOLDER ASSEMBLY IN A CARBON REMOVING CLEANING AGENT ("GUNK", "BENDIX CLEANER" OR EQUIVALENT) FOR AT LEAST 4 HOURS BEFORE REMOVING NOZZLE CAP NUT; OTHERWISE, THE NOZZLE LOCATING PINS MAY BE DAMAGED.**

4. Injection nozzle and holder assembly should be clamped down and attached to a workbench to prevent it from moving during disassembly.

5. Using a 19/32" 12 point box wrench, loosen nozzle cap nut. Loosen until cap nut can be turned by hand.

**NOTE:** A sharp blow to end of wrench may be required to break carbon bond between nozzle and cap nut.

6. Unclamp nozzle holder assembly.

7. Remove cap nut, nozzle spacer (with dowels) (†) and nozzle tip from holder body.

8. Remove spring seat, spring and shims from holder body. (See Figure 9.47.) Take care not to lose spacers (†).

##### ■ Cleaning and Inspection

All parts of the nozzle assembly should be thoroughly cleaned and inspected. Any parts showing damage or excessive wear should be replaced.

Special tools for performing nozzle cleaning operations are contained in nozzle cleaning set (SE- 2202). Hard or sharp tools, emery cloth, crocus cloth, grinding compounds or abrasives of any kind should never be used in the cleaning of nozzles.

SE-2202 Nozzle Cleaning Set Consists of:

**NOTE:** Order directly from: Bacharach, Inc.,  
625 Alpha Drive, Pittsburgh, PA 15238.

<u>Description</u>	<u>Qty.</u>
Honing Stone	1
Pin Vise, 0-.075"	1
Tallow, 1/2 oz. Tube	1
Brass Wire Brush, 1" x 3'	1
Tool Box (Wood, Sliding Lid)	1
Pressure Chamber Scraper	1
Polishing Sticks, 5 mm (60° Seat)	Set of 3
Valve Seat Scraper (60° Seat)	1
Inspection Magnifier (Loupe) 5x	1

(†) Spacers are used only in "B" code nozzles manufactured by UTDS.



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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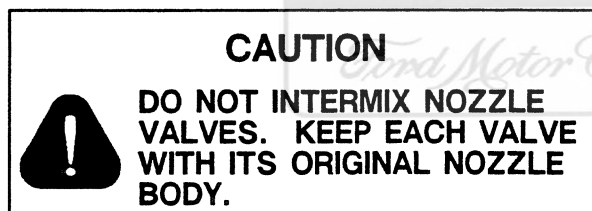
### FUEL INJECTION NOZZLES

#### ■ Cleaning and Inspection – Continued

SE-2202 Nozzle Cleaning Set – Continued

Description	Qty.
Polishing Sticks, 5 mm (90° Seat)	Set of 3
Valve Seat Scraper (90° Seat)	1
Nozzle Sac Hole Reamers .046"	Set of 2
Nozzle Sac Hole Reamers .050"	Set of 2
Nozzle Sac Hole Reamers .069"	Set of 2
Spray Hole Cleaning Needles .010"	Set of 5
Spray Hole Cleaning Needles .011"	Set of 5
Spray Hole Cleaning Needles .012"	Set of 5
Spray Hole Cleaning Needles .013"	Set of 5
Spray Hole Cleaning Needles .014"	Set of 5
Spray Hole Cleaning Needles .015"	Set of 5
Spray Hole Cleaning Needles .021"	Set of 5

1. Wash all parts in a suitable cleaning agent.



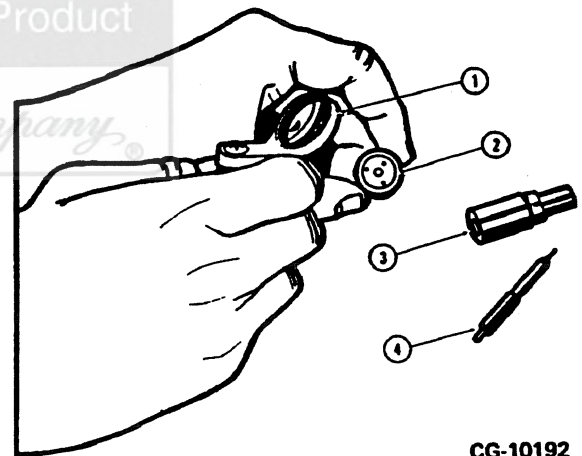
2. Soak nozzle in a carbon and varnish removing cleaning agent, such as #4300 Degreaser (TRICO Equipment Company of Chicago), or equivalent, for 30 minutes.
3. Clean outer surface and tip of nozzle valve body with brass wire brush and soft cloth. **DO NOT** scrape carbon from surface around pintle or damage may result.
4. The nozzle valve can be cleaned with mutton tallow used on a soft cloth or felt pad. The valve may be held by its upper stem in a revolving chuck during this operation. A piece of wood well soaked in oil or a brass wire brush will be helpful in removing carbon from the valve.
5. Clean all ducts and surface around pintle with filtered compressed air after rinsing with cleaning agent.
6. Thoroughly clean interior of nozzle cap nut. All carbon deposits must be removed (soak to loosen – brass brush to clean).

Inspect for cracks or damaged threads, replace if necessary.

7. Using a magnifying glass (1, **Figure 9.45**), inspect mating surfaces of nozzle components, particularly the nozzle spacer (2), nozzle valve body (3) and valve (4) for nicks, scratches or signs of corrosion. Failure of these surfaces to seal properly will result in leakage to the return or to the outside of the nozzle. Make certain that the nozzle spacer (2) pins are not broken or deformed.

If necessary, recondition these surfaces by flat lapping.

**NOTE: Never lap the valve-to-body seat. This will only widen the seat area and prevent sealing.**



**Figure 9.45. Inspecting Mating Surfaces**

1. Magnifying Glass
2. Nozzle Spacer w/Dowels
3. Nozzle Valve Body
4. Nozzle Valve

8. Check the stem and the body of the valve. When both parts are wet with fuel oil, no sticking should be evident. Pull the valve out of the body about one third of its length. When released, the valve should slide freely back to the seat. Foreign matter or scratches on the valve will cause it to stick. Carefully inspect before installing the valve.

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION NOZZLES

##### ■ Cleaning and Inspection – Continued

9. Inspect the nozzle cap nut for cracks, damaged threads or damaged copper gasket seating face and replace it if necessary.

10. OPENING PRESSURE ADJUSTMENT: The nozzle opening pressure is increased or decreased by the addition or removal of adjusting shims.

**NOTE:** Each .001 in. increase in shim thickness, increases the opening pressure by approximately 55 psi.

##### IMPORTANT

IF ANY COMPONENT FAILS TO MEET THE VISUAL INSPECTION CRITERIA UNDER THE MAGNIFYING GLASS AS DESCRIBED IN PARAGRAPH 7 OR IF THE VALVE STICKS AS EXPLAINED IN PARAGRAPH 8, REPLACE WITH A NEW NOZZLE AND HOLDER ASSEMBLY OR A NEW NOZZLE TIP ASSEMBLY, AS REQUIRED.

##### ■ Flat Lapping Procedures

**NOTE:** Use lapping block set SE-2250. Obtain directly from: Bacharach, Inc., 625 Alpha Drive, Pittsburgh, PA 15238.

1. Prepare the lapping blocks for use by washing them in fuel oil and using a bristle brush. Dry off with filtered compressed air. **DO NOT USE WIPING RAGS.**

2. Mix a small amount of lapping compound (1000 grit) into a thin paste using calibrating fluid.

**NOTE:** In some areas, prepared lapping compound can be obtained in small tubes.

3. Apply a very small amount of lapping compound (well spread out) to the lapped side of the block. Keep this amount at a minimum to obtain the best results.

**NOTE:** Blocks that are grooved on both sides are generally marked to indicate which side is the lapped surface.

4. The part to be lapped should be placed upon the lapping block and moved about in a figure eight pattern.

To equalize the wear in the lapping block, the series of figure eight strokes should start at one side and progress across the block as shown in Figure 9.46.

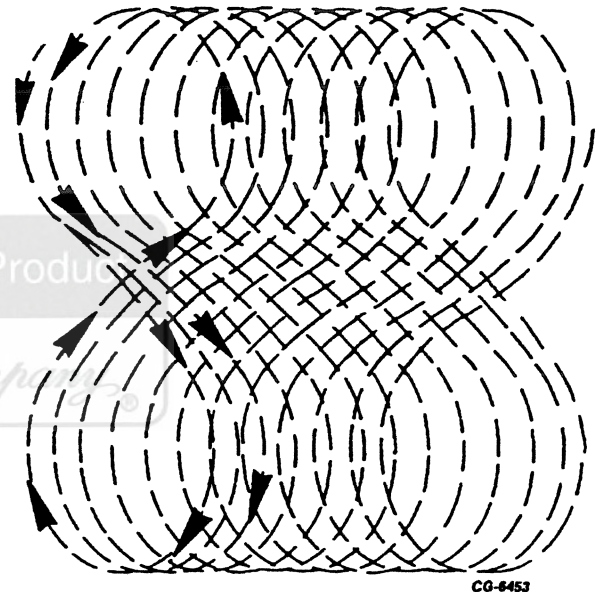


Figure 9.46. Pattern of Strokes Used for Flat Lapping

5. Apply only enough pressure to keep the part flat on the block. After four or five "passes", lift the part off the block and clean the compound off by rubbing the part across a clean sheet of paper placed on a flat surface. (Avoid excessive lapping.) If the surface of the lapped part does not appear uniform in reflected light or if there are any depressions around the sealing surfaces, repeat the lapping procedure above (see Note).

**NOTE:** When the lapping process does not remove depressions or provide good sealing surfaces, the component must be replaced with a new one.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Flat Lapping Procedures – Continued

6. Perform the last step, **DRY LAPPING**, which produces a mirror-like finish and provides an excellent sealing surface. Proceed as follows:

a. Clean the block in the same manner as described earlier and dry with filtered compressed air. The block used **MUST BE FREE OF ANY LAPPING COMPOUND**.

b. Place the part to be lapped on the block surface and move it about in a figure eight pattern across the whole area of the block (**Figure 9.47**). Make four or five passes, then inspect the finish before repeating (if necessary).

c. Apply only enough pressure to keep the part flat on the block.

**NOTE: Do not handle parts on the lapped surfaces as corrosion will appear in the areas as touched.**

**IMPORTANT**  
**KEEP THE LAPPING BLOCKS COVERED WHEN NOT BEING USED, TO KEEP DUST OR OTHER FOREIGN MATTER FROM THE SURFACE.**

#### ■ Care of Lapping Blocks

It will be necessary to perform a certain amount of maintenance on the lapping blocks to keep them in top condition. The wear will be gradual but, by continued use, worn or low spots in the block must be removed.

A short time spent each day in hand-lapping the blocks will be an effective way of maintaining the finish necessary for quality lapping.

#### ■ Reconditioning the Lapping Blocks

The lapping blocks must be thoroughly cleaned before any reconditioning is started. Use a stiff bristle brush (not a wire brush) and scrub the blocks in a good solvent and blow dry with filtered compressed air.

All lapping blocks in a set are involved in the reconditioning procedure outlined below:

1. Spread a small amount of 1000 grit lapping compound (prepared in a paste) on block number 1, assuming the blocks to be numbered 1, 2 and 3.

2. Lap number 1 and 2 (face to face) together, using the figure eight pattern (**Figure 9.46**). Then take 1 and 3; and finally 2 and 3.

After working 1 and 3 together, wipe off number 2 on a clean sheet of paper placed on a flat surface. Low spots, if any, will appear as dark spots and high spots as bright spots. Continue the lapping procedure until the overall appearance is a uniform grey surface.

3. After the blocks have been refinished, clean them thoroughly in a good solvent using a bristle brush, then blow dry with filtered compressed air.

#### ■ Reassembly (Nozzle Components)

After cleaning, inspecting, reconditioning and/or replacing the disassembled nozzle components, reassemble as follows: (Refer to **Figure 9.47**.)

1. Place nozzle holder in a vise standing in a vertical position.

**NOTE: Do not touch lapped surfaces. To avoid interchanging nozzle parts, reassemble one nozzle at a time.**

2. Dip all parts in clean calibrating fluid. Do not touch mating surfaces of components with fingers after dipping.

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

### FUEL INJECTION NOZZLES

#### ■ Reassembly (Nozzle Components) – Continued

3. Install pressure adjusting shims, pressure adjusting spring and spring seat into nozzle holder body.

**NOTE:** The thickest shim of the pack should contact the pressure adjusting spring.

4. Install nozzle spacer on holder body assuring that locating dowels are positioned correctly.

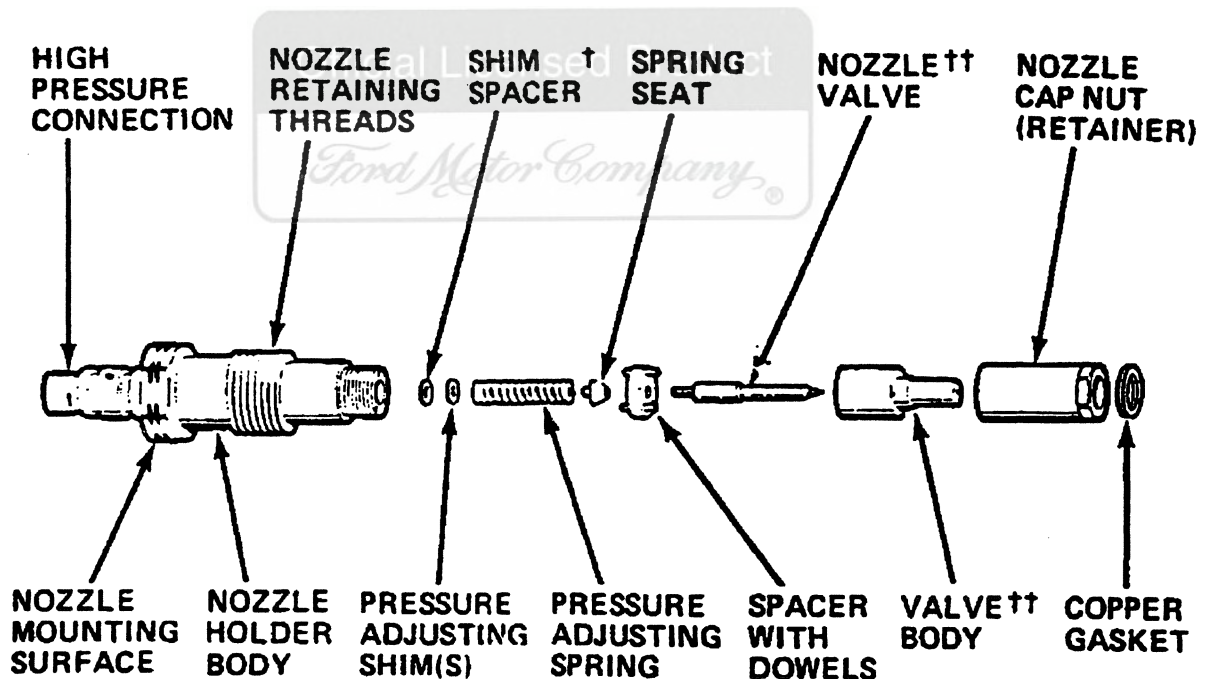
5. With nozzle valve dipped in clean calibrating fluid, assemble valve into nozzle body and move valve up and down several times to assure the valve **DOES NOT STICK**.

6. Apply a thin, even coat of "Lubriplate – 630 AAA", or equivalent, to the nozzle body seating shoulder, align nozzle body locating pin holes with spacer pins and assemble nozzle to spacer.

**NOTE:** Hold nozzle tightly against nozzle spacer while tightening.

7. Secure assembly with nozzle cap nut turned hand-tight. Be sure nozzle tip is concentric with holder.

8. With nozzle clamped securely in a soft jawed vise, tighten nozzle cap nut using a 19/32" 12 pt. box wrench. Tighten to the specified torque using a torque wrench.



† USED ON STANADYNE "C" AND "D" CODE NOZZLE ONLY. "BB" CODE NOZZLES USE PRESSURE ADJUSTING SHIM(S) WITHOUT SPACERS.

†† NOZZLE VALVE AND VALVE BODY CREATE THE NOZZLE TIP ASSEMBLY.

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Figure 9.47. Nozzle and Holder Assembly – Exploded View



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

Maximum permissible opening pressure for a reconditioned nozzle is:

#### ■ Retesting and Adjusting Clean Nozzle Assemblies

Maximum Permissible VOP  
(Reconditioned Nozzle)  
 $1875 \pm 75$  psi  
(12,928  $\pm$  517 kPa)

#### CAUTION



KEEP HANDS AWAY FROM THE NOZZLE DISCHARGE. FLUID DISCHARGING FROM THE NOZZLE UNDER HIGH PRESSURE CAN PENETRATE THE SKIN AND CAUSE INFECTION. MEDICAL ATTENTION SHOULD BE PROVIDED IMMEDIATELY IN THE EVENT OF SKIN PENETRATION.

NOTE: A .001 inch change in the shim pack will result in a 55 psi (379 kPa) change in pressure.

- NOZZLE TIP LEAKAGE: Blow nozzle tip dry using filtered compressed air. Operate test pump to maintain pressure at about 200 psi (1378 kPa) below the opening pressure obtained in Test 1. Wetting of the nozzle tip is acceptable as long as a drop does not fall within 5 seconds. (Refer to Figure 9.44.)

1. Mount the nozzle holder assemblies which have been disassembled, cleaned, inspected and reconditioned in nozzle test pump ZTSE-4045-A.

NOTE: Make sure that any fluid accumulation at the nozzle tip is not due to fuel leaking down the outside of the nozzle body from the return openings. If questionable, wrap a shop cloth around the nozzle body to prevent fluid leaking down the outside of the nozzle body from reaching the tip.

Refer to "Injection Nozzle Testing" in this section for test pump operation.

2. Test each nozzle for nozzle opening pressure and nozzle tip leakage as follows:

- OPENING PRESSURE TEST: Operate the pump handle in slow even strokes to bring the system pressure up. Note the highest pressure reached prior to the nozzle opening. Repeat operation, increasing handle speed if necessary, to establish consistent readings.

Minimum permissible opening pressure for a used nozzle is:

Minimum Permissible VOP  
(Used Nozzle)  
1425 psi (9825 kPa)

NOTE: Disregard tip leakage during this test and remember testing of spray pattern is no longer required.

#### CAUTION



DO NOT WIPE NOZZLE TIP WITH FINGERS AS INJURY COULD OCCUR AS A RESULT OF HIGH PRESSURE FUEL BEING RELEASED IF THE PINTLE VALVE IS MOVED INWARD. FUEL COULD PENETRATE THE SKIN CAUSING INJURY.

Leakage at the seat may be caused by dirt or foreign material carbon or gum deposits at the seat area or excessive wear of the seat. If the seat is worn, replace the nozzle valve and nozzle valve body.

After nozzles meet testing standards and adjustments are made, you may install nozzle assemblies.



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION NOZZLES

##### ■ Installation

1. Remove protective caps from nozzle tip and bore. Then install nozzle and holder assembly, with a new copper gasket, into the cylinder head nozzle bore.



**CAUTION**  
Be careful not to strike nozzle tip against recess wall during installation.

2. Tighten nozzle and holder assembly to specified torque (see "SPECIFICATIONS").

3. Remove protective covers from the fuel inlet end of the nozzle and from high pressure fuel lines.

4. Install two new O-ring seals on each nozzle holder body and install the leak-off lines and tees as an assembly after nozzle installation. Refer to Figure 9.48A-D for fuel return line routing.

**NOTE:** Install line sensor on No. 4 cylinder nozzle, prior to injection pipe installation. Tighten line sensor to the specified special torque.

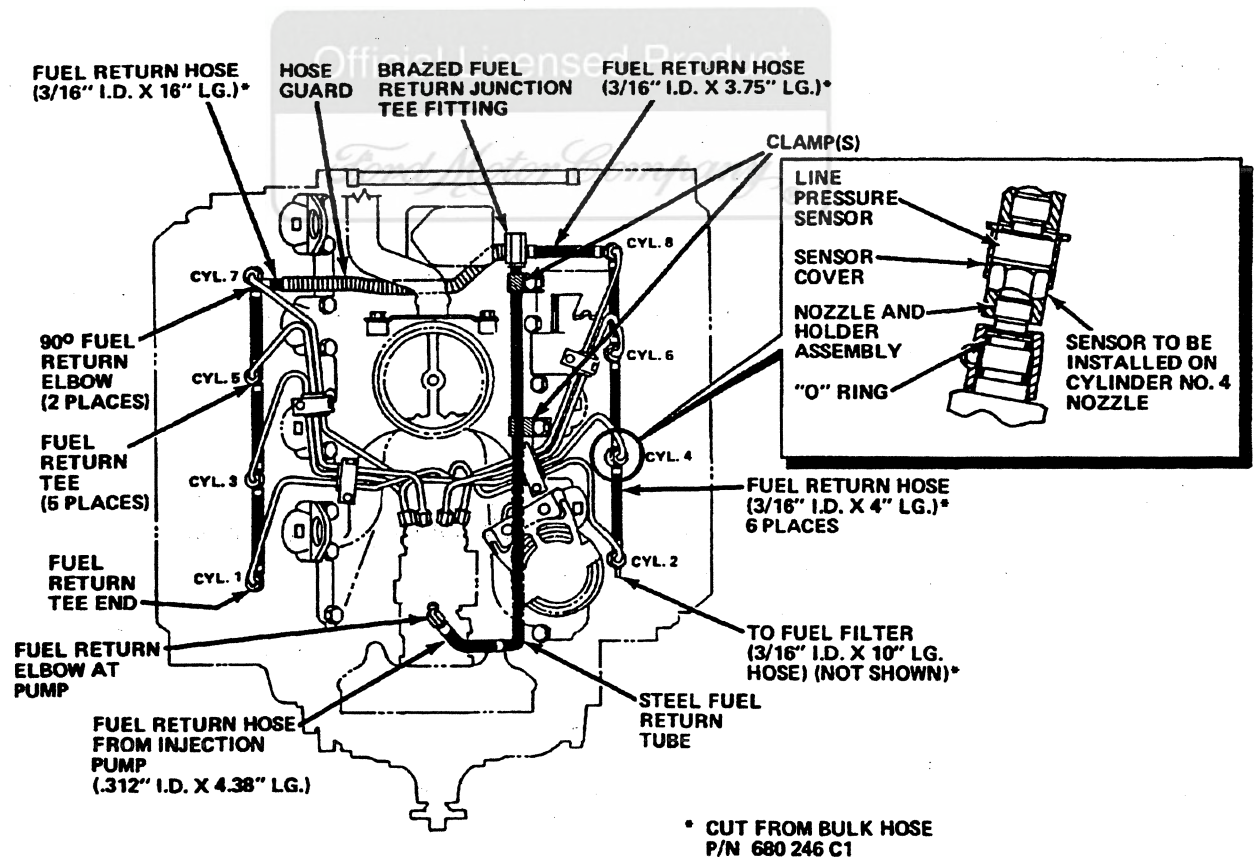


Figure 9.48A. EARLY MODEL Fuel Return Line Routing and Installation  
[All Applications Except U-HAUL]

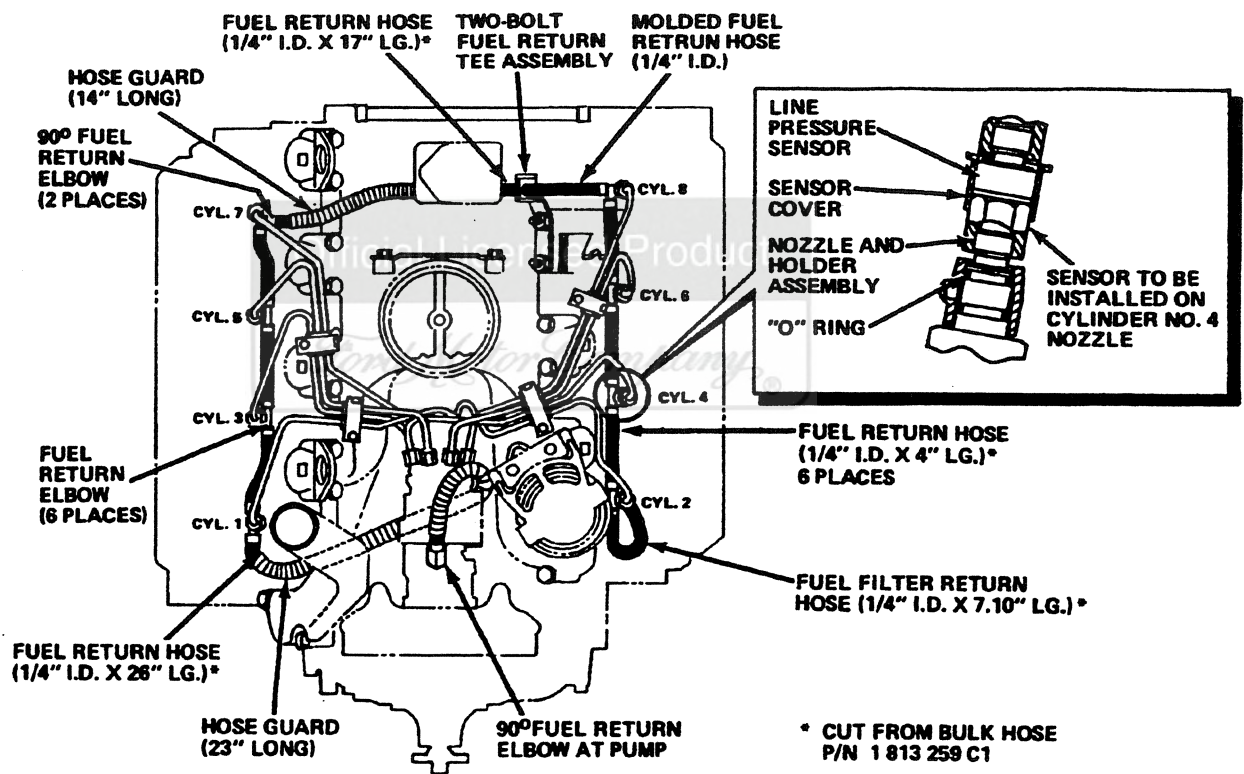
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## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Installation - Continued



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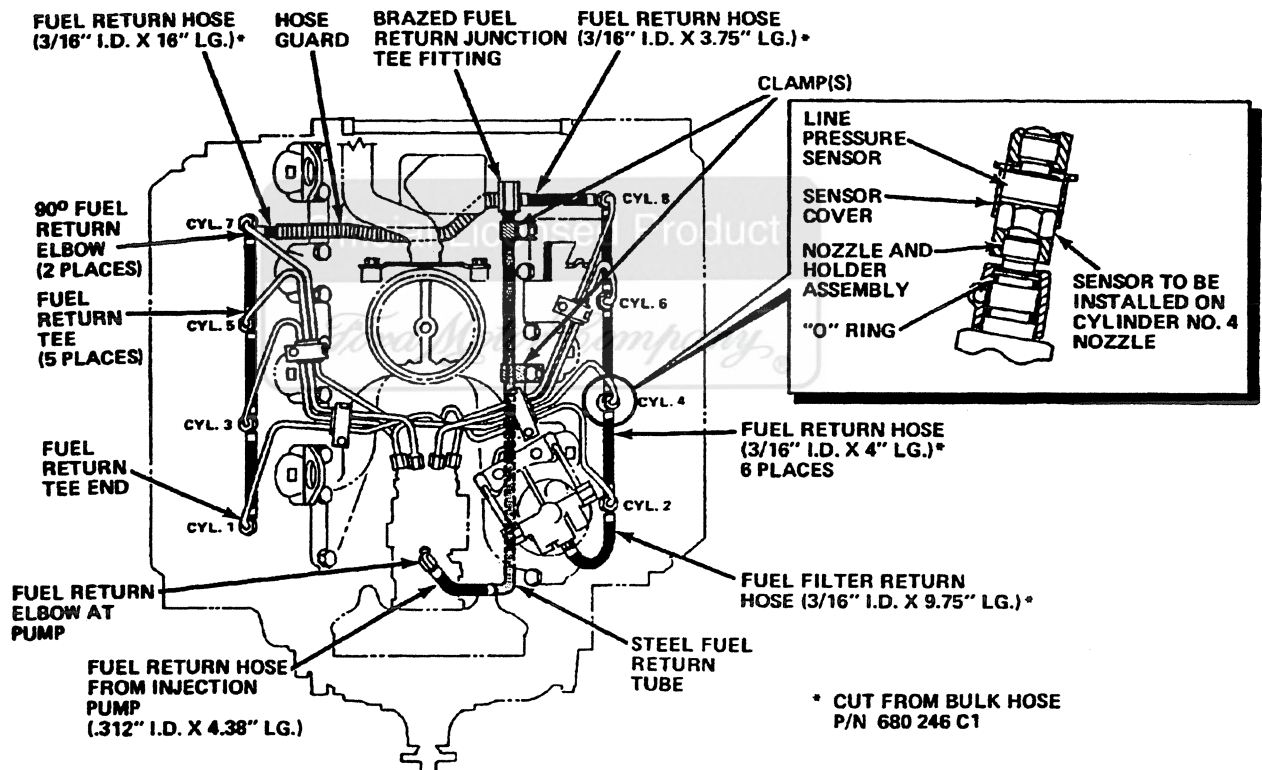
**Figure 9.48B. LATE MODEL Fuel Return Line Routing and Installation  
[All Applications Except U-HAUL]**

# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

### FUEL INJECTION NOZZLES

#### ■ Installation – Continued



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Figure 9.48C. EARLY MODEL Fuel Return Line Routing and Installation  
[U-HAUL Applications only]

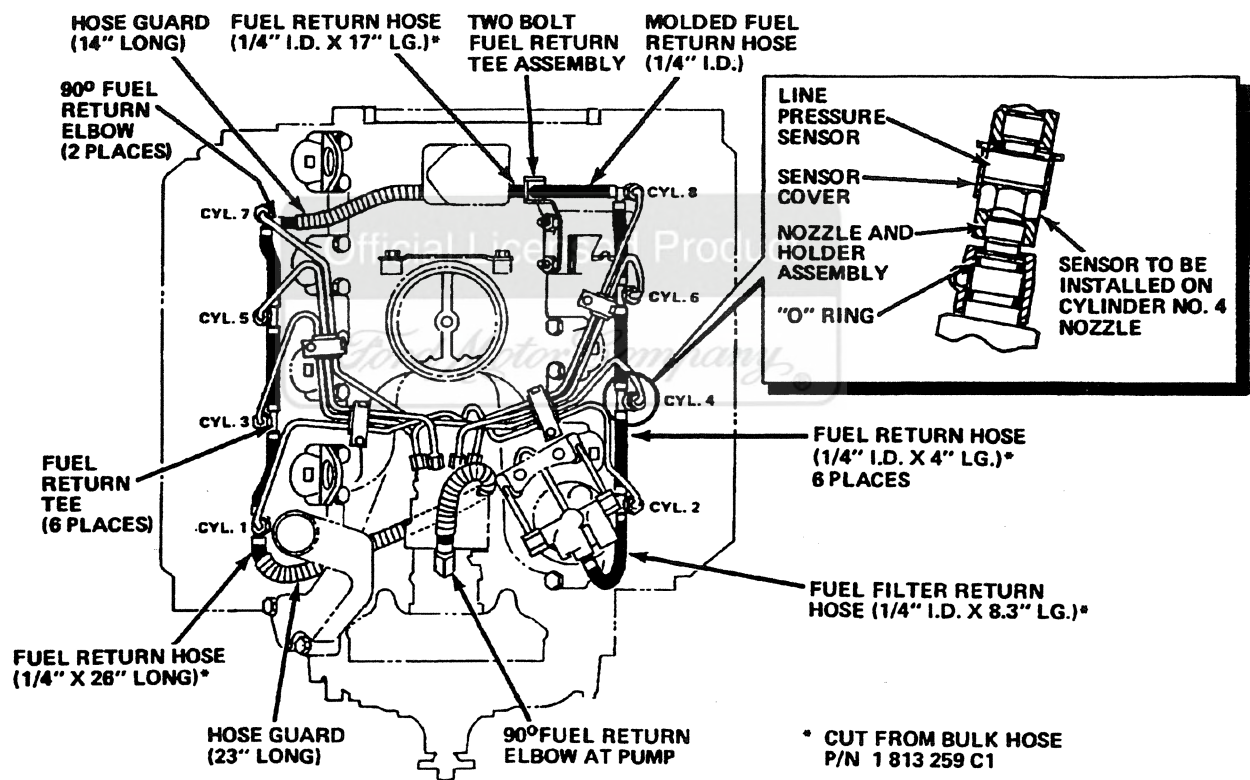
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## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### FUEL INJECTION NOZZLES

#### ■ Installation - Continued



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**Figure 9.48D. LATE MODEL Fuel Return Line Routing and Installation  
[U-HAUL Applications only]**

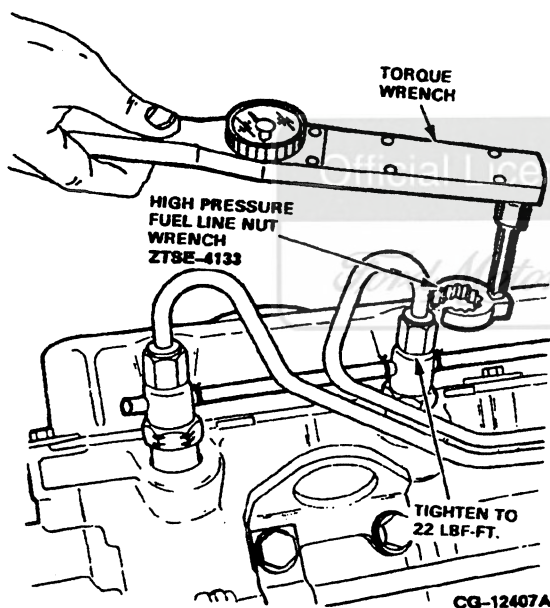
## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### FUEL INJECTION NOZZLES

##### ■ Installation - Continued

5. Connect high pressure fuel pipes to nozzle. Tighten fuel pipe connector nut to specified torque (see "SPECIFICATIONS"). Refer to **Figure 9.49**. Use fuel line nut wrench ZTSE-4133 to tighten the connector nuts to nozzles.



**Figure 9.49. Installing High Pressure Fuel Pipes**

6. Purge high pressure fuel pipes of air by loosening connector and cranking engine until solid fuel, free from air, flows from connection. Retighten connection to specified torque.

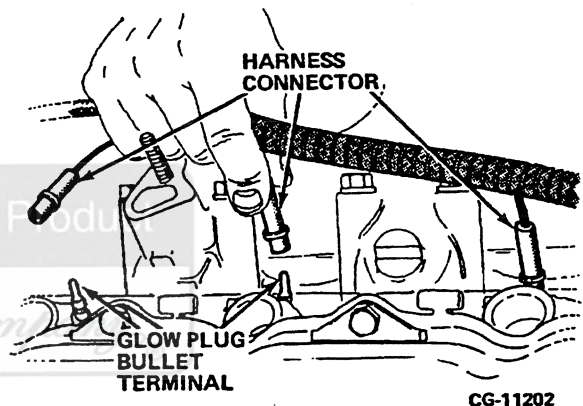
7. Start engine and check for fuel leakage at high pressure connections and leak-off lines.

#### GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)

##### ■ Removal

#### Glow Plug Harness and Controller

1. Disconnect the 8 push-on connectors from the glow plug "bullet" terminals. Refer to **Figure 9.50**.



**Figure 9.50. Harness Connector Removal**

2. Disconnect the following harness connectors: (Refer to **Figure 9.54A** or **9.54B**)

- At Injection Pump
  - Electric shut-off connector
  - Housing pressure cold advance
  - Cold idle solenoid

3. Disconnect the harness connector at the coolant temperature sensor in the left cylinder head. Refer to **Figure 9.51D**.

**NOTE:** Effective on 7.3 Diesel Engines with S/N 777 968 and above, the glow plug harness assembly is revised, reinstating a "HARD SHELL" connector for the coolant temperature switch. The "HARD SHELL" connector replaces the "SOFT SHELL" molded connector. Refer to **Figure 9.51A**.



# SERVICE MANUAL

## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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GLOW PLUG HARNESS, CONTROLLER AND  
GLOW PLUGS (Removal & Reassembly)

### ■ Removal - Continued

### Glow Plug Harness and Controller - Continued

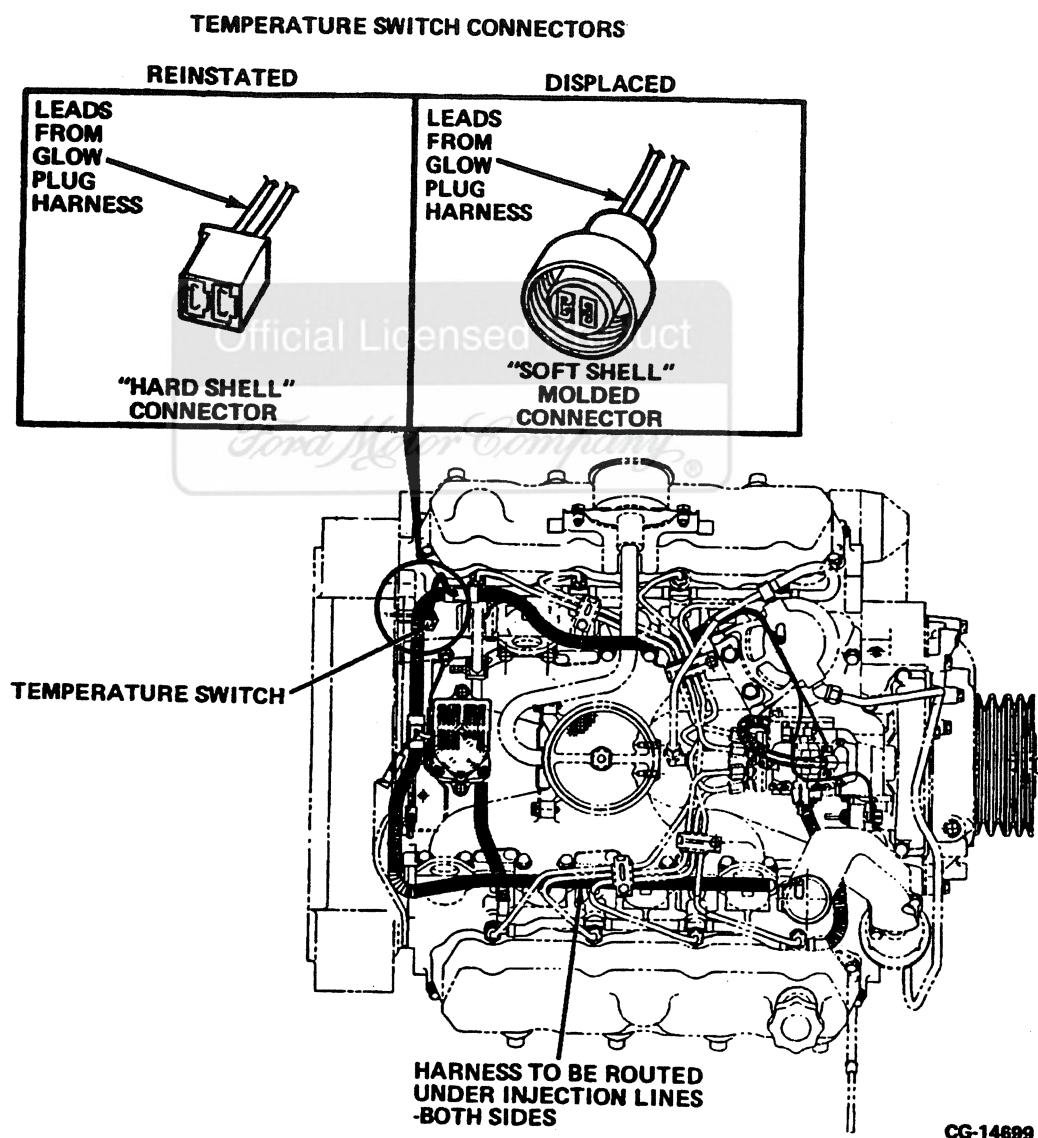


Figure 9.51A. Temperature Switch Connectors and Location

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)

##### ■ Removal – Continued Glow Plug Harness and Controller – Continued

The following CHART shows Glow Plug Harness evolution:

<u>Engine/Model</u>	<u>Harness P/N</u>	<u>Serial No.</u>
7.3L 1000, 3000 & 4000 SERIES	1 807 648 C94	● 777 968 and above (w/Reinstated "HARD SHELL" connector)
7.3L 1000, 3000 & 4000 SERIES	1 807 648 C93	● 579 900 – 777 967 (w/"SOFT SHELL" connector)
7.3 S-SERIES	1 807 648 C93	● 500 001 – 579 899 (w/Prior "HARD SHELL" connector)
6.9 S-SERIES w/ Solid State Glow Plug System	1 807 648 C93	● 246 734 and Above w/Prior "HARD SHELL" connector)

#### - IMPORTANT -

THE "SOFT SHELL" AND "HARD SHELL" CONNECTORS ARE PART OF THE GLOW PLUG HARNESS ASSEMBLY AND ARE NOT SERVICED SEPARATELY. WHEN REPLACING THE GLOW PLUG HARNESS ASSEMBLY WITH THE REVISED HARNESS (P/N 1 807 648 C94), VERIFY THE TYPE OF COOLANT TEMPERATURE SWITCH [REFER TO FIGURE 9.51B]. IF THE ENGINE IS EQUIPPED WITH THE THERMO-DISC PHASE II, THE SWITCH MUST BE REPLACED WITH THE HI-STAT PHASE III SWITCH.

To date, three coolant temperature switches have been used in subject engines. Refer to **Figure 9.51B**.

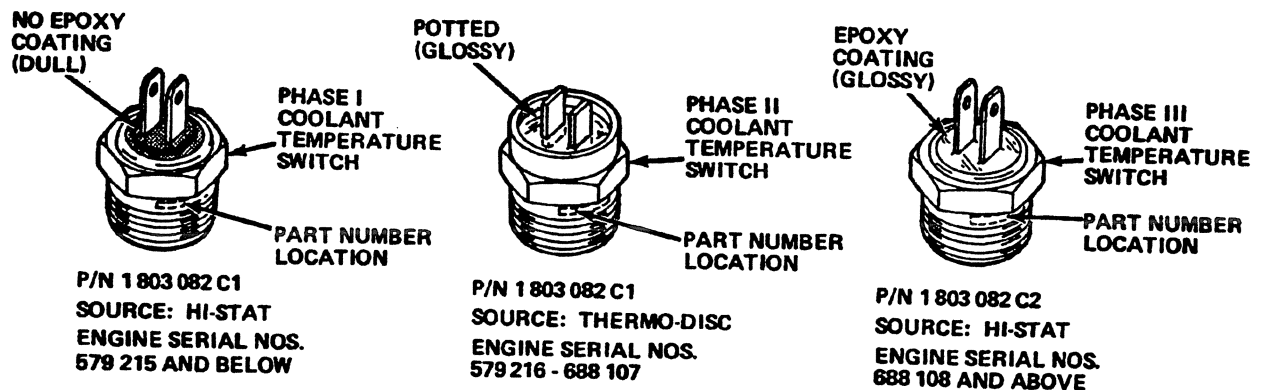


Figure 9.51B. Coolant Temperature Switch Comparison

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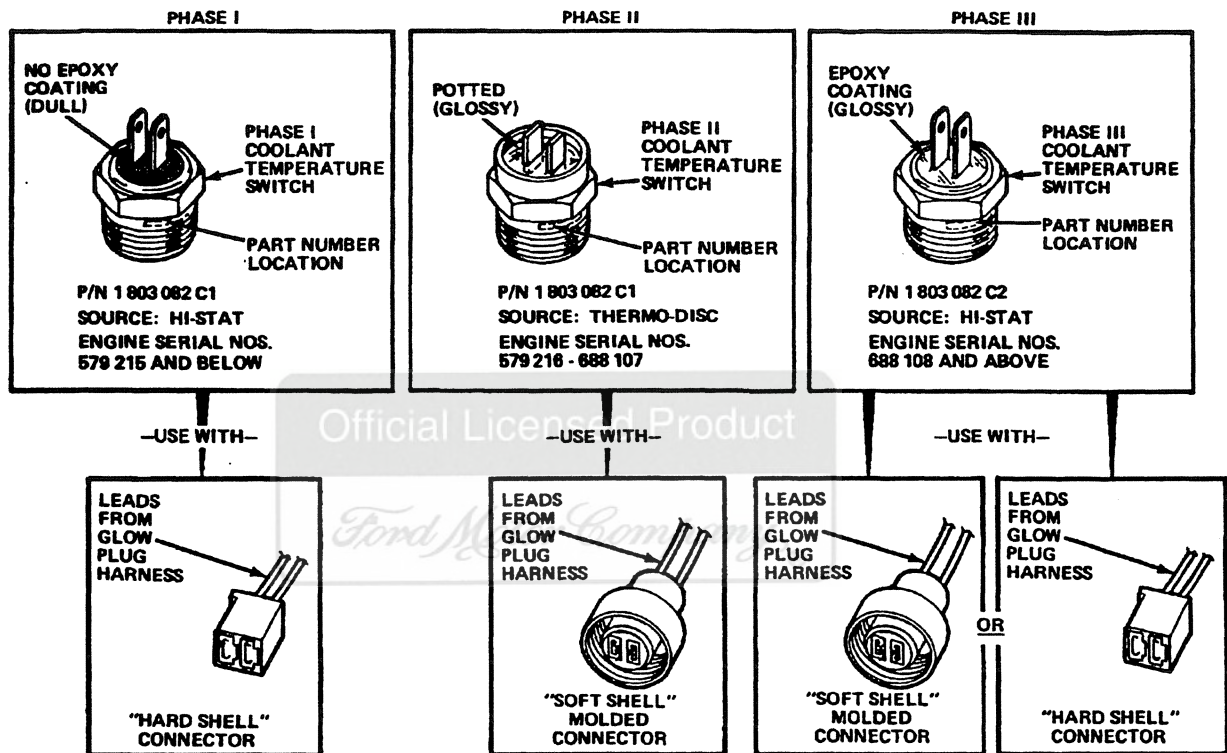
## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)

#### ■ Removal - Continued Glow Plug Harness and Controller - Continued

Only certain coolant temperature switches and glow plug harness connectors may be used with one another as shown in Figure 9.51C.



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Figure 9.51C. Glow Plug Harness Connector and Coolant Temperature Switch Combinations

4. Remove the nut and washer from the ground ring terminal. Refer to Figure 9.51D.

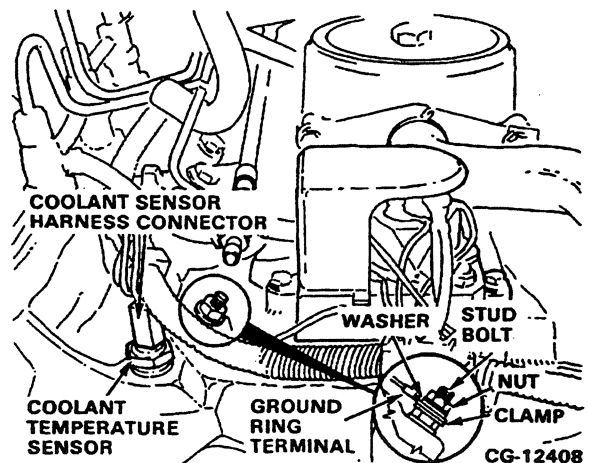


Figure 9.51D. Ground Wire and Coolant Sensor Harness Connector Removal

## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)

##### ■ Removal – Continued

#### Glow Plug Harness and Controller – Continued

5. Remove the engine mounted glow plug control unit by removing the two bolts and washers which fasten the control unit to the intake manifold. Refer to **Figure 9.52**. Lift the control unit (with harness from the engine). Pay attention to harness routing for reassembly.

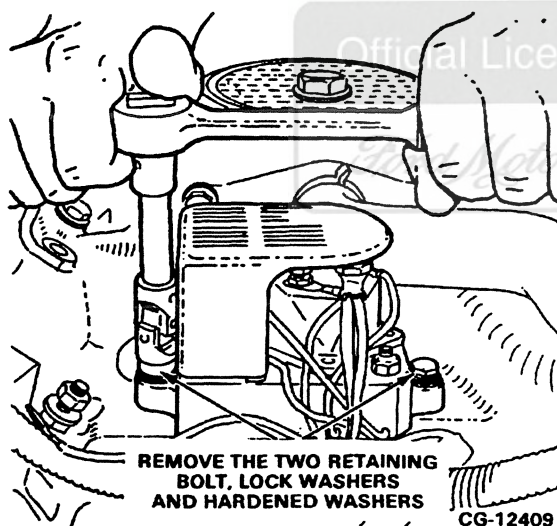


Figure 9.52. Glow Plug Controller Removal

#### Glow Plugs

1. Use a 3/8" deep well socket to remove the glow plugs.

**NOTE:** No special glow plug socket is required when servicing solid state glow plugs with bullet connectors.

2. Remove the glow plug from the bore in the cylinder head. Refer to **Figure 9.53**.

**NOTE:** It is not required to remove the glow plug harness and control unit prior to removing the glow plugs.

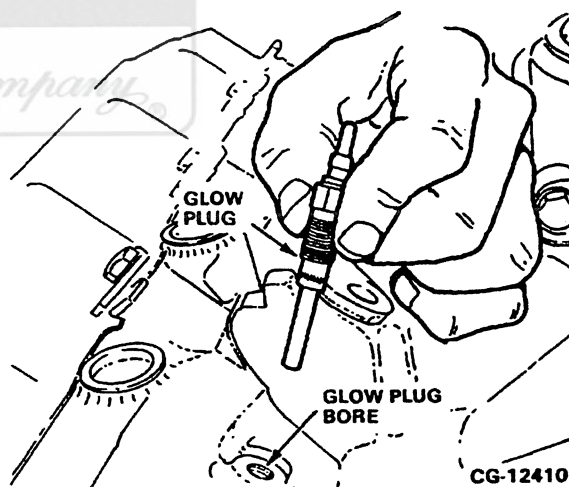


Figure 9.53. Glow Plug Removed

**IMPORTANT**  
FOR DETAILED INFORMATION ON  
INSPECTION AND REPAIR OF THE  
GLOW PLUG SYSTEM, REFER TO  
CGED-470-3 7.3 LITER SOLID STATE  
GLOW PLUG TROUBLESHOOTING  
GUIDE.

# **SERVICE MANUAL**

## **INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS**

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**Section 9**  
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### **GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)**

#### **Glow Plugs – Continued**

##### **■ Reassembly**

#### **Glow Plug**

1. Install glow plug and tighten to specified special torque using a 3/8 in. deep socket (see "SPECIFICATIONS").

#### **Glow Plug Harness and Controller (Refer to Figure 9.54A & 9.54B)**

1. Route harness as shown in Figure 9.54A or 9.54B

**NOTE:** Harness must be under the injection lines on both sides of the engine.

2. Bolt control unit onto the intake manifold. Tighten bolts to a standard torque of 7 lbf-ft.  $\pm 1$  lbf-ft. (10 Nm  $\pm 1$  Nm) using a calibrated torque wrench. **DO NOT OVERTIGHTEN TO PREVENT CONTROL UNIT HOUSING DAMAGE.**
3. Install the ground ring terminal and harness clamp arranging the washers and nuts as depicted in Figure 9.51.
4. Reconnect the following connectors: (Refer to Figure 9.54A or 9.54B .)

- Electric shut-off connector
- Housing pressure cold advance
- Cold idle solenoid
- Glow plugs
- Coolant temperature sensor



## SERVICE MANUAL

### INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

#### GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)

##### ■ Reassembly – Continued

##### Glow Plug Harness and Controller – Continued

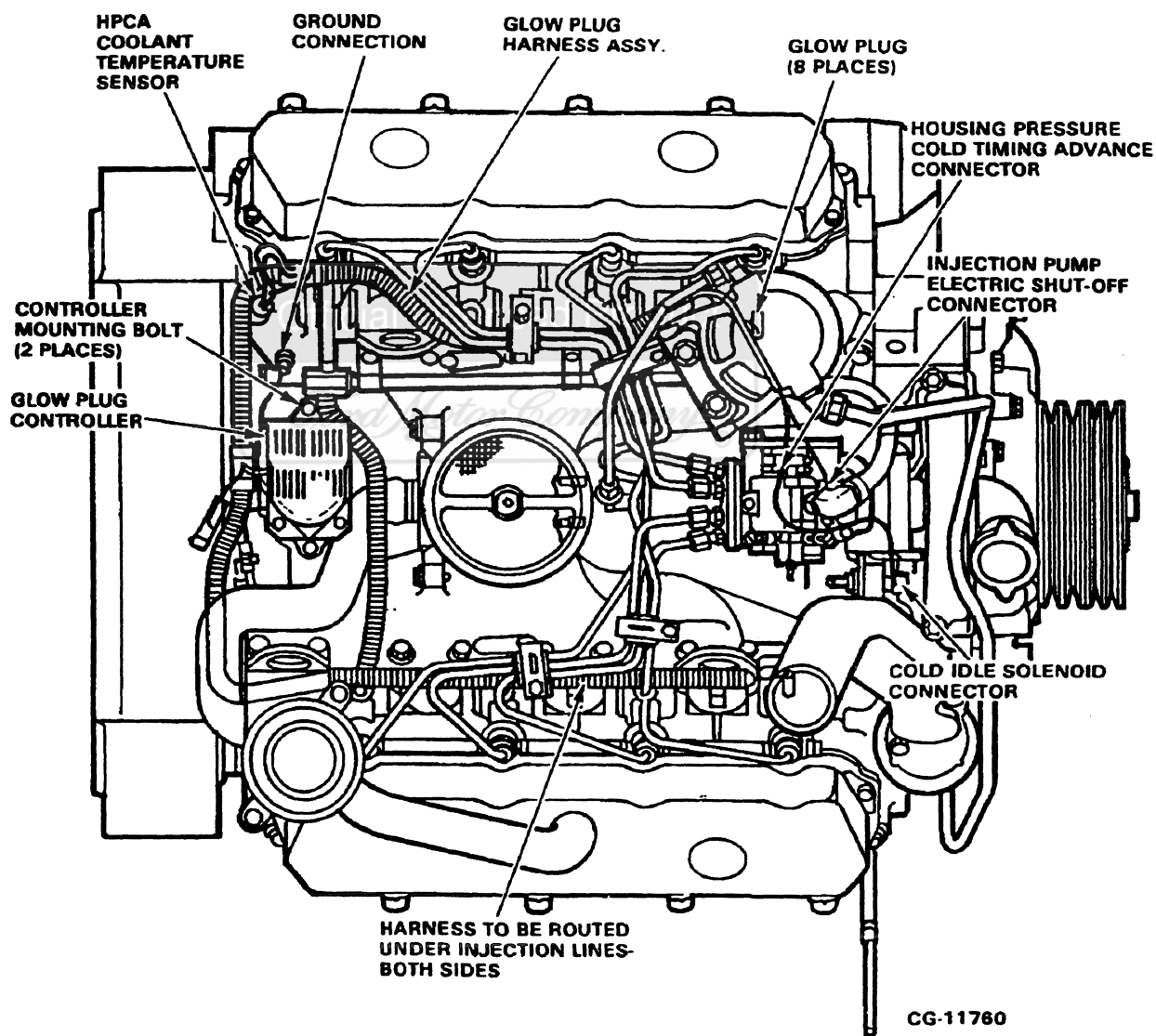


Figure 9.54A. Glow Plug Harness Routing and Connector Locations  
[1988 Model Year and Earlier shown]

# SERVICE MANUAL

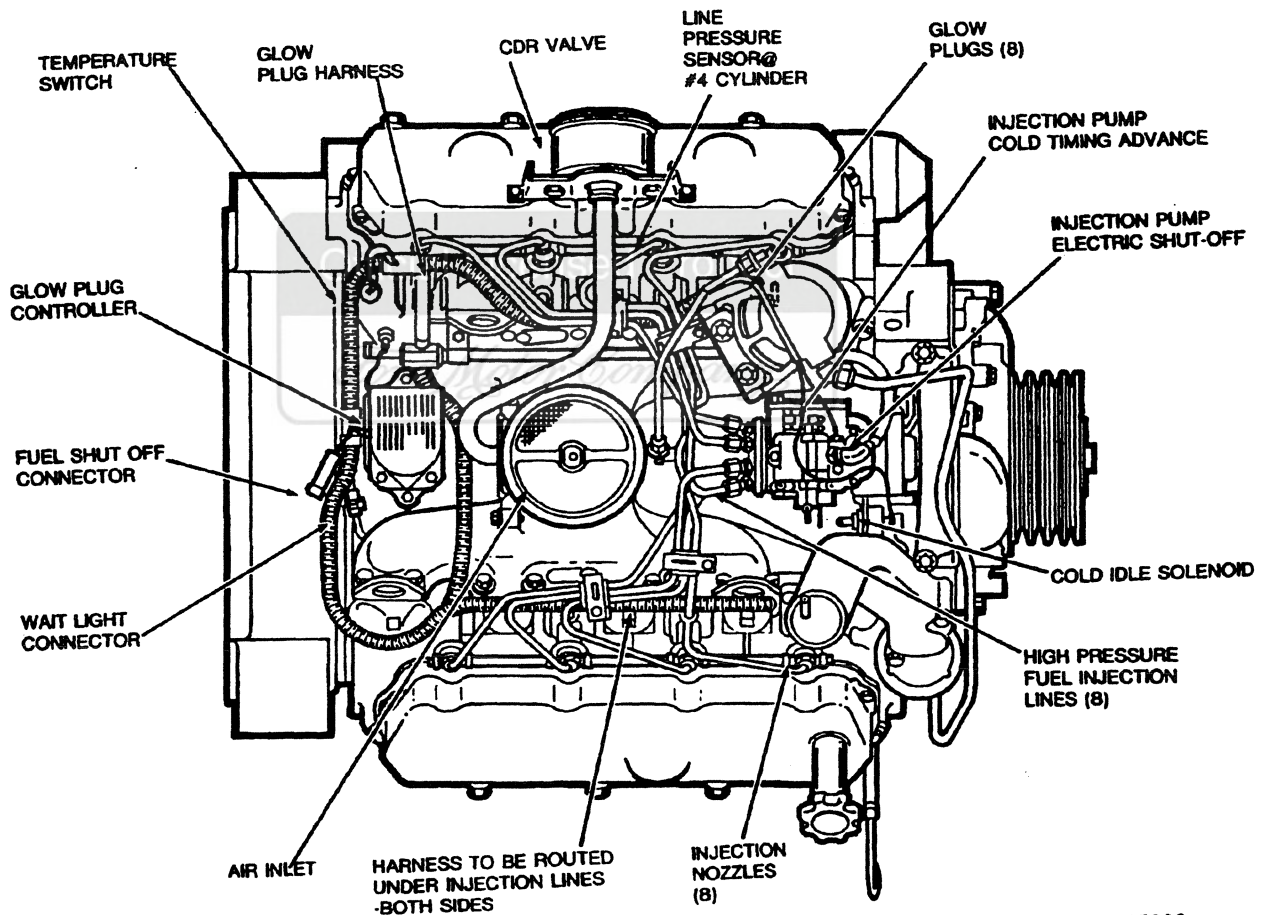
## INJECTION PUMP, NOZZLES, FUEL FILTER, SUPPLY PUMP AND GLOW PLUGS

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### GLOW PLUG HARNESS, CONTROLLER AND GLOW PLUGS (Removal & Reassembly)

#### ■ Reassembly - Continued

#### Glow Plug Harness and Controller - Continued



CG-15003

Figure 9.54B. Glow Plug Harness Routing and Connector Locations  
[1989 Model Year and Later]

# SERVICE MANUAL

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# SERVICE MANUAL

## GENERAL ENGINE SPECIFICATIONS

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### 7.3 Liter Engine Specifications

Engine Specifications	English			Metric		
Engine Models	A-130, A-155 and A-170					
Number of Cylinders	8					
Configuration	Vee					
Bore	4.11 Inch			104.39 mm		
Stroke	4.180 inch			106.20 mm		
Displacement	444 cu. in.			7.3 Liters		
Compression Ratio	21.5:1					
Firing Order	1-2-7-3-4-5-6-8					
Engine Rating	A-130	A-155	A-170	A-130	A-155	A-170
Brake Power @ 2700 RPM	130 BHP					
Brake Power @ 3000 RPM		155 BHP	170 BHP	97 KW	115.6 KW	126.7 KW
Peak Torque @ 1600 RPM	272 lb.ft.	304 lb.ft.	332 lb.ft.	368 N•m	412 N•m	450 N•m
Low Idle (No Load)#	675 RPM					
Governor Speed (No Load)	2950 3170 RPM	3250 - 3470 RPM				
Governor Speed (Full Load Rated)	2700 RPM	3000 RPM				
Timing (Static)	Align Marks @ 10:00 position					
Valve Tappet Clearance	0 (Valve Lash)					
Engine Lube Oil Pressure (Engine at Operating Temperature) Low Idle, Minimum High Idle	10 psi 40 - 70 psi			69 kPa 276 - 482 kPa		
Maximum Exhaust Restriction	41 Inches H <sub>2</sub> O			10.1 kPa		
Maximum Intake Restriction	25 Inches H <sub>2</sub> O			6.0 kPa		
Crankcase Capacity (without Filter)	15 quarts			14.2 Liters		
Crankcase Capacity (wlth Filter)	16 quarts			15.1 Liters		
Thermostat Opening Temperature	192 ° F			89 ° C		

# Manual transmission in Neutral position.  
Automatic transmission in Drive position.

## SERVICE MANUAL

### COMPONENT SPECIFICATIONS

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#### EXHAUST VALVES:

Stem Diameter	0.37165–0.37235 in. (9.4399–9.4577 mm)
Stem to Guide Clearance (Max. Allowable Before Replacement)	0.0055 in. (0.140 mm)
Face to Stem Run-Out (T.I.R. Max.)	0.0015 in. (0.0381 mm)
Valve Face Angle	37.5°
Valve Face Margin (Min.)	0.053" (1.35 mm)

#### INTAKE VALVES:

Stem Diameter	0.37165–0.37235 in. (9.4399–9.4577 mm)
Stem to Guide Clearance (Max. Allowable Before Replacement)	0.0055 in. (0.140 mm)
Face to Stem Run-Out (T.I.R. Max.)	0.0015 in. (0.0381 mm)
Valve Face Angle	30°
Valve Face Margin (Min.)	0.112 in. (2.84 mm)

#### CYLINDER HEADS:

Bore Diameter in Cylinder Head	
Valve Guide Insert (Service)	0.6234–0.6244 in. (15.834–15.859 mm)
Valve Guide O.D. (Service)	0.6248–0.6252 in. (15.87–15.88 mm)
Inside Diameter of Valve Guide Inserts (Service)	0.3736–0.3746 in. (9.489–9.514 mm)
Valve Guide Bore Finish (Micro inches)	63–93
Valve Guide Bore Run-Out	0.002 in. (0.05 mm)
Valve Guide Taper (Max.)	0.005 in. (0.127 mm)
Valve Guide Length (Service)	2.600 in. (66.04 mm)
Valve Seat Width (Int. & Exh.)	0.065–0.095 in. (1.651–2.413 mm)
Valve Seat Angle (Int.)	30°
Valve Seat Angle (Exh.)	37.5°
Valve Seat Run-Out (T.I.R. Max.)	0.002 in. (0.05 mm)
Valve Seat Insert O.D. (Exhaust Only)	1.6671–1.6681 in. (42.34–42.37 mm)
Valve Seat Insert I.D. (Exhaust Only)	1.366–1.376 in. (34.696–34.950 mm)
Valve Seat Insert Counterbore Diameter – Cylinder Head	1.6645–1.6655 in. (42.28–42.30 mm)
Gasket Surface Flatness	0.003 in. (0.0762 mm) in 6 inches; 0.006 inches (0.1524 mm) overall
Gasket Surface Finish (Micro inches)	63–125
Deck to Deck Dimension (Head Thickness Overall)	4.795–4.805 in. (121.793–122.047 mm)
Pre-Combustion Chamber Insert	
Recession/Protrusion	–0.0025 in./+0.0025 in. (–0.064 mm/+0.064 mm)

Valve Head Recession Relative to Deck (Head Gasket) Surface on Cylinder Head:

Intake	0.042–0.054 in. (1.06–1.37 mm)
Exhaust	0.051–0.063 in. (1.29–1.60 mm)

Valve Springs: [Serviced only as an assembly (P/N 317 365 C11)]

Valve Spring w/Damper

Free Length	2.075"±.150" (52.705 mm ±3.8 mm)
Test Length	1.397" (35.48 mm)
Test Load	200 lbs. ± 8 lbs.

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# SERVICE MANUAL

## COMPONENT SPECIFICATIONS

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Page 3

### CAMSHAFT

Bearing Journal Diameter (All Journals)	2.0900"–2.1000" (53.31–53.34 mm)
Bearing (Bushing) Diameter	2.1015"–2.1025" (53.37–53.40 mm)
Journal/Bushing Running Clearance	0.0015"–0.0035" (0.038–0.089 mm)
Shaft End Play	0.002"–0.009" (0.025–0.228 mm)
Timing Gear Backlash	0.0015"–0.013" (0.038–0.330 mm)
Lobe Surface Finish	12 RMS
Maximum Permissible Cam Lobe Wear	0.020" (0.51 mm)
Journal Surface Finish	16 RMS
Lobe Taper	.0002" (0.005 mm)
Camshaft Thrust Flange Thickness	0.4305"–0.4355" (10.93–11.06 mm)
Camshaft Lift	
Intake	0.2535" (6.44 mm) Max.
Exhaust	0.25308" (6.43 mm) Max.
Valve Timing No. 1 Cylinder (Top of Ramp)	
Intake Open	17.2° BTDC
Closed	42.8° ABDC
Exhaust Open	51.2° BBDC
Closed	20.8° ATDC

### HYDRAULIC VALVE LIFTERS

Diameter	0.9209"–0.9217" (23.391–23.411 mm)
Bore Diameter in Block	0.9228"–0.9243" (23.439–23.477 mm)
Clearance in Bore	0.0011"–0.0034" (0.027–0.086 mm)
Bleed-down Rate	20–110 Sec. for 0.125" Travel*

\*Time required for plunger to move 0.125" under 50 lbs load with **test fluid at room temperature.**

Type	Roller Follower
------	-----------------

### PUSH ROD

Run Out (Max. TIR)	0.015" Max.
--------------------	-------------

### CONNECTING RODS:

Material	I-Beam Section – Steel Forging
Rod Length Center to Center	7.128"–7.132" (181.05–181.15 mm)
Bushing Bore Diameter (Pin End)	1.235"–1.236" (31.37–31.39 mm)
Bushing Bore Finish	63–125 RMS
Piston Pin Bushing I.D.	1.1105"–1.1108" (28.20–28.21 mm)
Bearing Bore Diameter (Crankshaft End)	2.6905"–2.6915" (68.34–68.36 mm)
Maximum Out of Round	0.0005" (0.0127 mm)
Maximum Taper/Inch	0.0005" (0.0127 mm)
Connecting Rod Bearing I.D.	2.5001"–2.5016" (63.50–63.54 mm)
Connecting Rod Bearing Running Clearance	0.0011"–0.0036" (0.0280–0.091 mm)
Connecting Rod Side Clearance	0.012"–0.024" (0.30–0.060 mm)
Connecting Rod Alignment ( Max. Total Difference)	
Twist	0.002"/in. (0.0508 mm/in.)
Bend	0.001"/in. (0.0254 mm/in.)
Weight – Complete rod without Bearing	1140–1156g.
Weight – at pin end (Non-Service Spec.)	328–336g.
Weight – at journal end (Non-Service Spec.)	812–820g.
Surface Finish – Bearing Bore (Crankshaft End)	50–90 RMS
Surface Finish – Installed Bushing (Pin End)	16 RMS

## SERVICE MANUAL

### COMPONENT SPECIFICATIONS

#### PISTONS:

Material ..... Aluminum Alloy  
Skirt Diameter (Measured 1.23" below oil groove at 90° to the piston pin). Measure only at room temperature 68° F. (20° C)

● Production Piston (See Note)

Class U .....	4.10325" ± 0.00025"	(104.223 mm ± 0.006 mm)
Class B .....	4.10375" ± 0.00025"	(104.235 mm ± 0.006 mm)
Class A .....	4.10425" ± 0.00025"	(104.248 mm ± 0.006 mm)
Class C .....	4.10475" ± 0.00025"	(104.261 mm ± 0.006 mm)
Class D .....	4.10525" ± 0.00025"	(104.273 mm ± 0.006 mm)

● Service Piston

Standard Size .....	4.10425" ± 0.00025"	(104.247 mm ± 0.006 mm)
.010" Oversize .....	4.11425" ± 0.0005"	(104.502 mm ± 0.013 mm)
.020" Oversize .....	4.12425" ± 0.0005"	(104.756 mm ± 0.013 mm)
.030" Oversize .....	4.13425" ± 0.0005"	(105.010 mm ± 0.013 mm)

**NOTE:** For corresponding bore diameters and class fit, refer to Section 6, SPECIFICATIONS

#### Clearance in Cylinder Bore

Cylinder No. 1 thru 6 ..... 0.0055"–0.0085" (0.0380–0.216 mm)

Cylinder No. 7 and 8 ..... 0.0060"–0.0085" (0.152–0.216 mm)

#### PISTONS PINS:

Length ..... 2.692"–2.702" (68.38–68.63 mm)

Diameter ..... 1.1099"–1.1101" (28.19–28.20 mm)

Pin Fit @ Room Temperature 20°C (68°F)

● Clearance in Rod ..... 0.0004"–0.0009" (0.010–0.022 mm)

● Clearance in Piston ..... 0.0003"–0.0007" (0.007–0.018 mm)

#### PISTON RINGS:

##### Ring Diameter (Standard)

Top ..... 4.11" (104.39 mm)

2nd ..... 4.11" (104.39 mm)

Oil Control ..... 4.11" (104.39 mm)

##### Fit in Groove (Side Clearance) [Engine S/N 598753 and Below]

Top ..... 0.002"–0.004" (0.05–0.10 mm)

2nd ..... 0.002"–0.004" (0.05–0.10 mm)

Oil Control ..... 0.001"–0.003" (0.02–0.07 mm)

##### Fit in Groove (Side Clearance) [Engine S/N 598754 and Above]

Top ..... 0.002"–0.004" (0.05–0.10 mm)

2nd ..... 0.003"–0.005" (0.07–0.12 mm)

Oil Control ..... 0.001"–0.003" (0.02–0.07 mm)

##### Ring Gap in Bore [Engine S/N 598753 and Below]

Top ..... 0.013"–0.045" (0.33–1.14 mm)

2nd ..... 0.060"–0.085" (1.52–2.16 mm)

Oil Control ..... 0.008"–0.030" (0.20–0.76 mm)

##### Ring Gap in Bore [Engine S/N 598754 and Above]

Top ..... 0.013"–0.023" (0.33–0.58 mm)

2nd ..... 0.062"–0.072" (1.57–1.83 mm)

Oil Control ..... 0.010"–0.020" (0.25–0.51 mm)

# SERVICE MANUAL

## COMPONENT SPECIFICATIONS

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### CRANKSHAFT:

Type .....	Steel Forging, Induction Hardened, Grindable
Main Bearing Journal Diameter	
• Standard Size .....	3.1228"-3.1236" (79.319-79.340 mm)
• .010" Undersize .....	3.1128"-3.1136" (79.065-79.085 mm)
• .020" Undersize .....	3.1028"-3.1036" (78.811-78.831 mm)
• .030" Undersize .....	3.0928"-3.0936" (78.557-78.577 mm)
Main Bearing Journal Max. Out-of-Round .....	0.0002" (0.005 mm)
Main Bearing Thrust Face Runout (TIR Max.) .....	0.001" (0.03 mm)
Main Bearing Journal Taper (Max./In.) .....	0.0005" (0.013 mm)
Main Journal Fillet Radius .....	0.121"-0.127" (3.07-3.22 mm)
Rod Journal Fillet Radius .....	0.120" (3.048 mm)
Oil Seal Journal Runout (Max.) .....	0.002" (0.05 mm)
Damper Mounting Area Runout (Max.) .....	0.001" (0.03 mm)
Flywheel Mounting Surface Runout (Max.) .....	0.002" (0.05 mm)
Number of Main Bearings .....	5
Thrust Taken By .....	Intermediate
Thrust Bearing Journal Length .....	1.1325"-1.1355" (28.766-28.841 mm)
Main Bearing I.D. (Installed) .....	3.1254"-3.1274" (79.385-79.436 mm)
Main Bearing to Crankshaft Clearance .....	0.0018"-0.0046" (0.046-0.117 mm)
Main and Rod Bearing Journal Finish .....	5-20 RMS
Main Bearing Thrust Face Finish .....	5-20 RMS
Connecting Rod Journal Diameter	
• Standard Size .....	2.498"-2.499" (63.45-63.47 mm)
• .010" Undersize .....	2.488"-2.489" (63.20-63.22 mm)
• .020" Undersize .....	2.478"-2.479" (62.94-62.96 mm)
• .030" Undersize .....	2.468"-2.469" (62.69-62.71 mm)
Connecting Rod Journal Max. Out-of-Round .....	0.0003" (0.008 mm)
Connecting Rod Journal Taper (Max./In.) .....	0.0005" (0.013 mm)
Connecting Rod Bearing to Crankshaft Running Clearance .....	0.0011"-0.0036" (0.028-0.091 mm)
Crankshaft Flange O.D. ....	3.748"-3.752" (95.199-95.300 mm)
Crankshaft End Play .....	0.0025"-0.0085" (0.063-0.215 mm)
Crankshaft End Play Max. Wear Limit .....	0.012" (0.304 mm)
Rod to Crankshaft Side Clearance .....	0.012"-0.024" (0.304-0.609 mm)
Crankshaft Straightness .....	0.002" (0.051 mm)
Crankshaft Gear Backlash .....	0.0015"-0.012" (0.038-0.30 mm)
Flywheel Runout .....	0.008" (0.20 mm)
Flywheel Concentricity .....	0.008" (0.20 mm)

### CRANKCASE:

Crankcase Deck Flatness .....	0.003" (0.076 mm)	Overall
Crankcase Deck Finish (Micro Inches) .....		63-125
Crankcase Main Bearing Bore Diameter .....	3.3152"-3.3162" (84.21-84.23 mm)	
Crankcase Cam Bearing Bore Diameter .....	2.2305"-2.2320" (56.65-56.69 mm)	
Valve Lifter Bore Diameter .....	0.9228"-0.9243" (23.44-23.48 mm)	
Valve Lifter O.D. ....	0.9209"-0.9217" (23.39-23.41 mm)	
Oil Jet Tube Bore Diameter (Spray Hole Dia.) .....	0.052" (1.37 mm)	
Cylinder Bore Diameter		
• Cylinder 1 thru 6 .....	4.1095"-4.1115" (104.38-104.43 mm)	
• Cylinder 7 and 8 Only .....	4.1100"-4.1120" (104.39-104.44 mm)	
Cylinder Bore Taper (Top to Bottom) .....	0.003" Max.	
Cylinder Bore Maximum Out-of-Round .....	0.002"	
Cylinder Bore Surface Finish .....	15-30 RMS	
Centerline of Main Bearing Bore to Head Deck .....	11.137"-11.141" (282.88-282.98 mm)	

## SERVICE MANUAL

### COMPONENT SPECIFICATIONS

#### CRANKCASE: – Continued

Oil Seals (Front and Rear Seal Face Runout)  
(with Plates Installed on Engine) ..... 0.015" T.I.R. Max. (0.381 mm)

Main Bearings  
Type ..... Precision Replaceable  
Material ..... Steel Backed Copper/Lead  
Thrust Taken By ..... No. 3 Main  
Cap Attachment ..... 4 Bolts per Cap  
Rear Plate Seal Bore Concentricity (T.I.R.) ..... 0.020" (0.05 mm)

#### THERMOSTAT

Type ..... Poppet Valve, Pellet operated

Start to Open Temp. (Deg. F)	Full Open Temp. (Deg. F)
192° $+0^{\circ}$ $-7^{\circ}$	212°

Operating Temperature Range .....

#### WATER PUMP

Type ..... Centrifugal, Prelubricated  
Drive/Ratio ..... V-Belt/1.08:1  
Bearing No-Type ..... 1- Sealed, Unitized  
Capacity (gpm @ engine rpm) ..... 70 @ 3000

#### LUBRICATING OIL PUMP:

Type ..... Gear Pump, Gear Driven  
Location ..... Inside Oil Pan  
Capacity (gpm @ rpm) ..... 18.2 @ 3000  
Gear Drive Ratio ..... 1.06:1  
Gear Backlash ..... 0.0056–0.010" (0.142–0.254 mm)  
End Play ..... 0.0025"–0.0065" (0.0635–0.1651 mm)  
Engine Lube Oil Pressure  
(Engine at Operating Temperature) ..... 10 psi (69 kPa) min. @ 700 RPM  
40–70 psi (276–482 kPa) @ Governor Speed RPM (No Load)

#### ENGINE OIL CAPACITY:

(Without Filter) ..... 15 Qts. (14.2 L)  
(With Filter) ..... 16 Qts. (15.1 L)

#### OIL COOLER:

Type ..... Full-Flow, Cylindrical Tube and Fin Bundle  
Location ..... Left Side of Engine

#### OIL FILTER:

Type ..... Spin-On, Full Flow – Disposable  
Location ..... Left Side, Oil Cooler Mounted  
Filter By-Pass Location ..... In Oil Filter Header

# SERVICE MANUAL

## COMPONENT SPECIFICATIONS

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### BY-PASS VALVE SPRING: (NOT SERVICED)

Free Length ..... 1.767 in. (44.88 mm)  
Test Length ..... 0.820 in. (20.83 mm)  
Test Load ..... 3.93 lbs. (17.5N)

### PRESSURE REGULATING VALVE SPRING: (NOT SERVICED)

Free Length ..... 1.547" (39.29 mm)  
Test Length ..... 0.915" (23.24 mm)  
Test Load ..... 5.82 ±.29 lbs (25.89 ±1.29 mm)

### PRESSURE REGULATING VALVE: (NOT SERVICED)

Location ..... Oil Filter Header (After the oil cooler and before the oil filter)  
Setting ..... 50 psi (344.7 kPa)

### INJECTION PUMPS

Model ..... Stanadyne DB-2  
Drive ..... Gear – Steel Forging  
Static Timing ..... Marks Aligned  
Minimum Voltage to Pump ..... 9 Volts

### NOZZLES

Type ..... Pintle  
Size ..... 17 mm  
Actuation ..... High Pressure Fuel from Fuel Injection Pump  
Pintle Hole:  
Number ..... 1  
Hole Diameter ..... 0.039 in. (1.0 mm)  
Valve Seat Angle ..... 60°  
Valve Opening Pressure (VOP)  
New ..... 1875±75 psi (12,928±517 kPa)  
Min. VOP before Replacement ..... 1425 psi (9825 kPa)

### FUEL SUPPLY PUMP

Type ..... Mechanical Diaphragm

### FUEL FILTER

Type ..... Spin-On

### GLOW PLUGS

Location ..... Cylinder Head  
Quantity ..... 8  
Thread Size ..... M10 X 1 (SAE J5480)



## SERVICE MANUAL ENGINE ACCESSORIES

### ACCESSORIES

Your engine may be equipped with the following accessories that must be removed prior to mounting the engine on the overhaul stand.

FREON COMPRESSOR  
ALTERNATOR  
POWER STEERING PUMP  
AIR COMPRESSOR

When reinstalling any accessory, provide special attention to the alignment and tension of the drive belt. Correct installation will prevent vehicle downtime and promote customer satisfaction.

New drive belts as well as reinstalled belts experience a break-in period. This break-in period causes a loss in tension during "groove-seating". Allow a newly installed belt to run 5 minutes (this is the break-in period). After 5 minutes running time, check belt tension as illustrated in **Figure 1** using a scale and straightedge.

Approximately 1/2"–3/4" (13 to 19 mm) deflection should be measured. The deflection measurement should be made between the longest belt span.

### Belt and Pulley Replacement

Replace belts if they are:

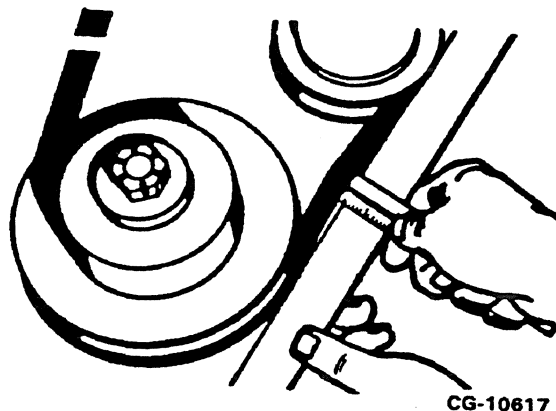
- a. Worn
- b. Cracked
- c. Grease Soaked
- d. Oil Soaked

Replace pulleys if worn. Clean if still suitable for service.

### FAN AND ALTERNATOR BELT ADJUSTMENT

#### Fan and Alternator Belt Adjustment:

1. Loosen alternator lock bolt and move alternator to increase or decrease belt tension.
2. After adjustment, tighten lock bolt and re-check belt tension.



**Figure 1. Checking Tension by Deflection Method**

### Belt Replacement Guidelines

1. During belt assembly, do not force belt(s) into pulley grooves by prying with a screwdriver, pry bar, etc. This will damage belt side cords which will cause belt(s) to turn over in pulley grooves and result in complete destruction of belt(s) during operation.
2. Do not use belt dressing on belt(s).
3. Always check condition of remaining belt(s).
4. In a dual-belt drive, always replace with a matched set of belts.
5. When replacing belt(s) and pulley, pulley alignment must be checked under tensioned condition (brackets securely clamped). A misalignment that can be detected by visual inspection is detrimental to belt(s) performance.
6. If belt(s) is disturbed for any reason, it must be tensioned to the correct tension.

### WARNING

**DO NOT PLACE HEAD, BODY, FEET, FINGERS OR HANDS NEAR A ROTATING FAN, BELT OR POWER DRIVEN PART. DO NOT CHECK OR ADJUST BELTS WHEN ENGINE IS RUNNING.**

### IMPORTANT

**OPERATING ENGINE WITH BELOW MINIMUM TENSION WILL RESULT IN BELT AND GROOVE DETERIORATION, BELT ROLL OR BELT ESCAPE.**

# SERVICE MANUAL

## TORQUE DATA

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### GENERAL TORQUE GUIDELINES

Many conditions affect torque and the results of torque applications. The major purpose in tightening a fastener to a specified torque is to obtain tension in the fastener (i.e., bolt, nut, etc.), which in turn develops a clamping load which exceeds any possible loading imposed on parts due to engine RPM or vibration.

### Tension Values for Standard Fasteners

The "Standard Nut and Bolt Torque Chart" provides tightening torque for general purpose applications using original equipment standard hardware as listed in the Parts Catalog for the application involved. **DO NOT SUBSTITUTE.** Original equipment standard hardware is defined as Type 8, coarse thread bolts and nuts and thru hardened flat washers (Rockwell "C" 38-45), all phosphate coated and assembled without

supplemental lubrication (as received condition). **NOTE: Phosphate coating is a dry lubricant.**

### Fastener Thread Condition

Threads that are dry, excessively rough, battered or filled with dirt require considerable effort just to rotate. Then when the clamping load is developed or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified torque value. However, the desired bolt tension and maximum clamping effect is not achieved. This condition can lead to failure of the fastener to maintain component integrity. The proper bolt tension and clamping effect can never be attained if the fastener is dry. The fastener threads must have a film of clean lubricant (engine oil) to be considered lubricated.

## STANDARD NUT AND BOLT TORQUE CHART

Nominal Thread Diameter	Standard Torque $\pm$ 10%	
	lbf-ft	N•m
1/4	7	10
5/16	14	19
3/8	24	32
7/16	38	51
1/2	60	80
9/16	80	110
5/8	115	155
3/4	200	270
7/8	320	440
1	480	650
1-1/8	590	800
1-1/4	830	1100
1-3/8	1100	1500
1-1/2	1400	1900
1-3/4	2300	3100
2	3400	4600

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### TORQUE DATA

#### SPECIAL NUT AND BOLT TORQUE DATA\*

	lbf-ft.	N•m
Air Cleaner Stud Adapter (See Note 1) .....	45	61
Camshaft Screw .....	15	20
Connecting Rod Nut (See Note 2) .....	51	69
Crankshaft Vibration Damper Bolt .....	90	122
Cylinder Head Bolt (See Note 3) .....	100	135
Exhaust Manifold bolt (with Metal Prevailing Torque Bolt) (See Note 4) .....	35	47
Flywheel Mounting Bolt .....	47	64
Front Engine Mounting Bolt .....	70	95
Fuel Filter Assembly - Threaded Insert .....	50	68
Fuel Filter Assembly Vent/Valve Assembly .....	3-5 lbf-in.	0.5
Glow Plug .....	12	16
Injection Line Pressure Sensor .....	28	38
Injection Nozzle .....	35	47
Injection Nozzle Cap Nut .....	33	45
Injection Pump Gear Cover Bolt (See Note 1) .....	14	19
Injection Pump Gear Mounting Bolt .....	25	34
Intake Manifold Bolt (See Note 5) .....	24	33
Intake Manifold Gasket Drain Plug .....	40	54
Main Bearing Cap Bolt (See Note 6) .....	95	129
Nut, Injection Pipe .....	22	30
Oil Pan Drain Plug .....	28	37
Valve Cover Bolt (See Note 7) .....	6	8
Valve Lever Post Bolt (See Note 8) .....	20	27
Water Outlet Elbow Mounting Bolt .....	20	27
Water Pump Mounting Bolts (See Note 9) .....	14	19

\*Unless otherwise specified, torque values are with threads and washer faces coated with clean engine oil.

NOTE 1 - Apply general purpose Lock N' Seal™ (P/N 577 588 C1) to all threads of bolts prior to assembly.

NOTE 2 - Tighten both connecting rod nuts to 38 lbf-ft. (51 N•m) before final torque is applied.

NOTE 3 - Cylinder head bolts to be torqued in steps as specified in **Figure 2**.

NOTE 4 - Apply "Never Seez" compound (P/N 634 227 C1) to threads of bolts prior to assembly, then torque in steps as specified in **Figure 4**.

NOTE 5 - Intake manifold bolt to be torqued in steps as specified in **Figure 5**.

NOTE 6 - Tighten four main bearing cap bolts to 75 lbf-ft. (102 N•m) before final torque is applied.

NOTE 7 - Valve cover screws to be torqued in sequence as specified in **Figure 3**.

NOTE 8 - Rotate engine until timing mark (notch) on vibration damper is approximately 20° before vertical position as viewed from the front of the engine, approximately 11:00 so valves cannot contact the piston. Refer to **Figure 7**. Tighten each pair of bolts evenly. Refer to **Figure 8**.

NOTE 9 - Clean bolts thoroughly. Apply liquid gasket (P/N 446 839 C1) to designated bolts (refer to **Figure 6**) only.

# SERVICE MANUAL

## TORQUE DATA

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### SPECIAL NUT & BOLT TORQUE DATA:

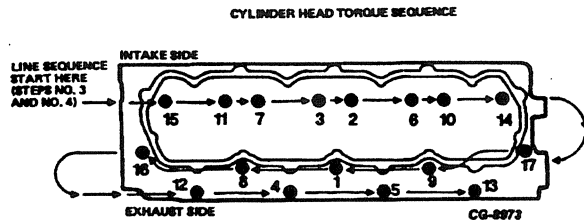


Figure 2. Cylinder Head Bolts

#### HEAD BOLTS

- STEP 1. 65 lbf-ft. (88 N•m)\*
- STEP 2. 85 lbf-ft. (115 N•m)\*
- STEP 3. 100 lbf-ft. (135 N•m)\*\*
- STEP 4. Repeat Step 3.

\*Tighten bolts in numbered sequence, Figure 2.

\*\*Tighten bolts in line sequence, Figure 2.

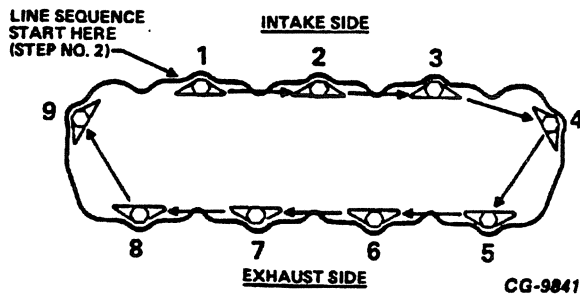


Figure 3. Valve Cover Torque Sequence

Install and tighten bolts to 6 lbf-ft. (8 N•m) in line sequence shown in Figure 3.

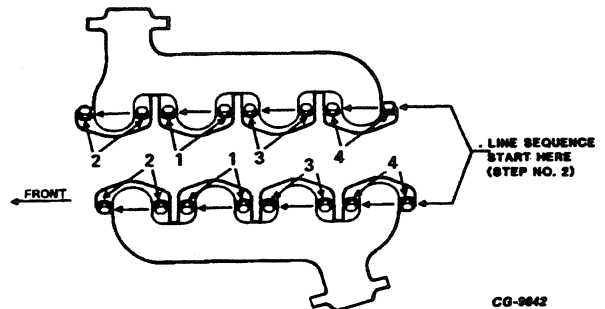


Figure 4. Exhaust Manifold Bolt Torque Sequence

- STEP 1. Tighten bolts to 35 lbf-ft. (47 N•m) in numbered sequence (Figure 4).

- STEP 2. Tighten bolts to 35 lbf-ft. (47 N•m) in line sequence (Figure 4).

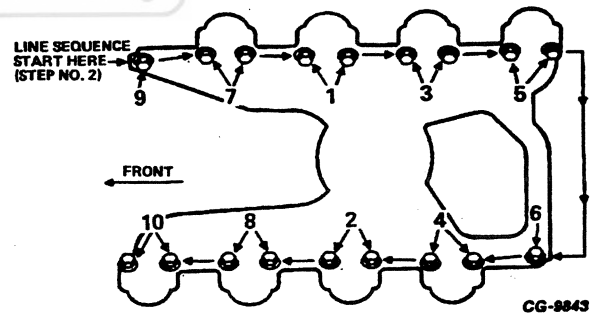


Figure 5. Intake Manifold Bolt Torque Sequence

NOTE: For ease of installation start corner bolts No. 9 and No. 6 by hand prior to performing Steps 1 and 2.

- STEP 1. Tighten bolts to 24 lbf-ft. (33 N•m) in numbered sequence as shown in Figure 5.

- STEP 2. Tighten bolts to 24 lbf.ft. (33 N•m) in line sequence as shown in Figure 5.

## SERVICE MANUAL TORQUE DATA

### SPECIAL NUT & BOLT TORQUE DATA: -

Continued

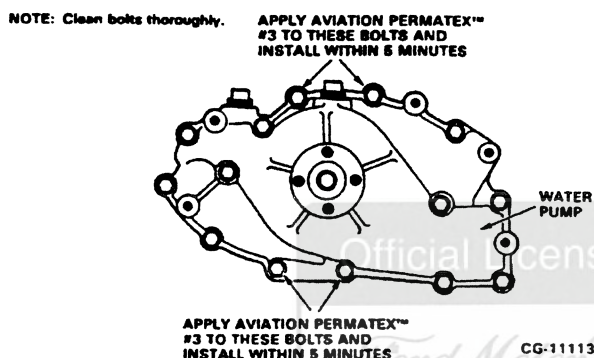


Figure 6. Water Pump Mounting Bolts

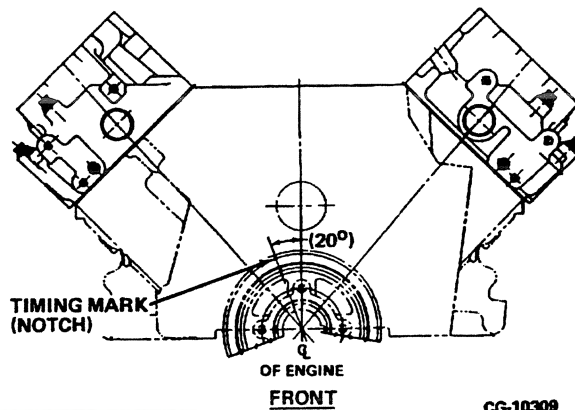


Figure 7. Engine Crankshaft Vibration Damper Timing Mark Positioned at 11:00 (20° from vertical) for Valve Lever Post Bolt Torque (Damper Behind Pulley)

#### IMPORTANT (Refer to Figure 7)

**STEP 1 - ROTATE ENGINE UNTIL TIMING MARK (NOTCH) ON VIBRATION DAMPER IS AT 11:00 (20° BEFORE VERTICAL). THIS POSITIONS ALL PISTONS BELOW TDC SO THE VALVES DO NOT CONTACT THE PISTONS WHEN TIGHTENING THE VALVE LEVER ASSEMBLIES.**

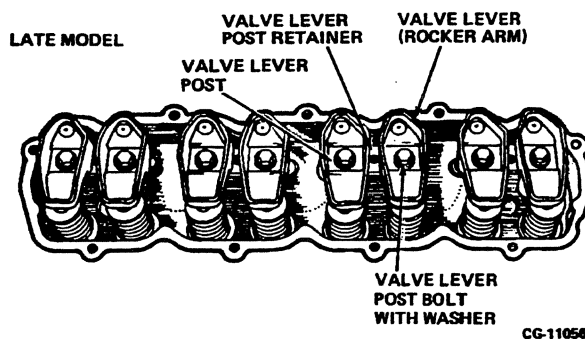


Figure 8. Valve Lever (Rocker Arm) Assembly

**STEP 2. Tighten each pair of valve lever post bolts down evenly to 20 lbf-ft (27 N•m).**



# SERVICE MANUAL

## SPECIAL SERVICE TOOL LIST

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MANUAL SECTION	TOOL DESCRIPTION	TOOL ORDER NO.
ONE	Engine Stand Engine Stand Mounting Adapter Plate	SE-4034 ZTSE-4151
TWO	Fuel System Protector Cap Set Intake Manifold Protector Cap	ZTSE-4135 ZTSE-4136
THREE	Valve Seat Grinding Set Valve Seat Cutter (Less Stones and Pilot) Fuel System Protector Cap Set Cylinder Head Lifting Sling Exhaust Valve Seat Remover  Valve Spring Tester Valve Spring Compressor  Valve Stem Seal Installer Valve Guide Service Tools Nozzle Holder Rack Exhaust Valve Seat Installer Expansion Plug Replacer Valve Guide Bore Gauge	ZTSE-1631-69 ZTSE-1631-A ZTSE-4135 SE-1896 ZTSE-1951-B & ZTSE-1951-21 ZTSE-2241 ZTSE-1846 or ZTSE-4137 ZTSE-4138 ZTSE-4157 ZTSE-4141 ZTSE-4164 ZTSE-4155-A SE-2506
FOUR	Camshaft Bushing Remover/Installer Set Fuel Pump Cam Remover/Installer Hydraulic Valve lifter Tester Damper, Crankshaft and Camshaft Gear Installer Damper, Crankshaft and Camshaft Gear Remover Camshaft Remover and Installer Adapter Slide Hammer 5/8"-18 Female to 1"-14 Female Adapter	ZTSE-1897-D SE-4156 ZTSE-1893 ZTSE-1900-69 ZTSE-2295-69 ZTSE-1880-D ZTSE-1879 SE-1879-5
FIVE	Honing Machine Connecting Rod Guide Protector Caps Connecting Rod Bushing Remover and Installer	SE-2218 ZTSE-4153 ZTSE-4154
SIX	Expansion Plug Replacer Boring Machine Cylinder Hone Camshaft Bushing Remover and Installer Damper, Crankshaft and Camshaft Gear Installer Damper, Crankshaft and Camshaft Gear Remover BRM Flex Hone®* Front Crankshaft Seal Installer Rear Crankshaft Seal Installer Rear Crankshaft Seal Protector Oil Leak Detector	ZTSE-4155-A SE-1399 SE-1574 SE-1897-69 ZTSE-1900-69 ZTSE-2295-69 GBD4-1/8* ZTSE-4130 ZTSE-4131 ZTSE-1942-2 SE-1632

\*Order directly from: Brush Research Manufacturing Co., Inc.  
4642 East Floral Drive  
Los Angeles, CA 90022  
(213) 261-2193

## SERVICE MANUAL

### SPECIAL SERVICE TOOL LIST

MANUAL SECTION	TOOL DESCRIPTION	TOOL ORDER NO.
SEVEN	No Special Service Tools Required	- - -
EIGHT	No Special Service Tools Required	- - -
NINE	Injection Pump Wrench Fuel Line Wrench Fuel System Protector Cap Set Nozzle Seat Cleaner Nozzle Holder Rack Nozzle Tester Nozzle Cleaning Kit+ Lapping Blocks+ Tach-N-Time Diesel Timing Tester	ZTSE-4132 ZTSE-4133 ZTSE-4135 ZTSE-4139 ZTSE-4141 ZTSE-4045-A SE-2202+ SE-2250+ ZTSE-4142

+Order directly from: Bacharach, Inc.  
 625 Alpha Drive  
 Pittsburgh, PA 15238

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## SPECIAL SERVICE TOOL LIST

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### CONVERSION TABLE

CONVERSION TABLE — INCH FRACTIONS AND DECIMALS TO MILLIMETER EQUIVALENTS											
INCHES		mm	INCHES		mm	INCHES		mm	INCHES		mm
Fract.	Dec.		Fract.	Dec.		Fract.	Dec.		Fract.	Dec.	
—	.0004	.01	—	.3	7.620	—	.7874	20	—	1.969	50
—	.001	.0250	5/16	.3125	7.938	51/64	.7969	20.241	2	2.000	50.8
—	.0039	.10	—	.3150	8	13/16	.8125	20.638	2 1/8	2.125	54
—	.005	.127	21/64	.3281	8.334	—	.8268	21	—	2.165	55
—	.0079	.2	—	.3346	8.5	53/64	.8281	21.034	2 1/4	2.250	57.2
—	.0098	.25	11/32	.3438	8.731	27/32	.8438	21.431	—	2.362	60
—	.01	.254	—	.3543	9	55/64	.8594	21.828	2 3/8	2.375	60.3
—	.0118	.3	23/64	.3594	9.128	—	.8662	22	2 1/2	2.500	63.5
1/64	.0156	.397	—	.3740	9.5	7/8	.8750	22.225	—	2.559	65
—	.0157	.4	3/8	.375	9.525	57/64	.8906	22.622	2 5/8	2.625	66.7
—	.0197	.5	25/64	.3906	9.922	—	.9	22.860	2 3/4	2.750	69.9
—	.0236	.6	—	.3937	10	—	.9055	23	—	2.756	70
—	.025	.635	—	.4	10.160	29/32	.9063	23.019	2 7/8	2.875	73
—	.0276	.7	13/32	.4062	10.319	59/64	.9219	23.416	—	2.953	75
—	.0295	.75	—	.4134	10.5	15/16	.9375	23.813	3	3.000	76.2
1/32	.0313	.794	27/64	.4219	10.716	—	.9449	24	—	3.150	80
—	.0315	.8	—	.4331	11	61/64	.9531	24.209	3 1/4	3.250	82.6
—	.0354	.9	7/16	.4375	11.113	31/32	.9688	24.606	—	3.346	85
—	.0394	1	29/64	.4531	11.509	—	.9843	25	3 1/2	3.500	88.9
3/64	.0469	1.191	15/32	.4688	11.906	1	1.000	25.400	—	3.543	90
—	.0472	1.2	—	.4724	12	—	1.024	26	—	3.740	95
—	.05	1.27	—	.4844	12.303	1 1/16	1.062	26.988	3 3/4	3.750	95.3
—	.0551	1.4	—	.4921	12.5	—	1.063	27	—	3.937	100
—	.0591	1.5	1/2	.5	12.700	—	1.102	28	4	4.000	101.6
1/16	.0625	1.588	—	.5118	13	1 1/8	1.125	28.575	—	4.331	110
—	.0669	1.7	33/64	.5156	13.097	—	1.142	29	4 1/2	4.500	114.3
—	.075	1.905	17/32	.5326	13.494	—	1.181	30	—	4.724	120
5/64	.0781	1.984	—	.5315	13.5	1 3/16	1.188	30.16	5	5.000	127
—	.0787	2	35/64	.5469	13.891	—	1.221	31	—	5.118	130
—	.0906	2.3	—	.5512	14	1 1/4	1.250	31.75	5 1/2	5.500	139.7
3/32	.0938	2.381	9/16	.5625	14.288	—	1.260	32	—	5.512	140
—	.0984	2.5	—	.571	14.5	—	1.299	33	—	5.906	150
—	1	2.540	37/64	.5781	14.684	1 5/16	1.312	33.34	6	6.000	152.4
—	.1024	2.6	—	.5906	15	—	1.339	34	—	6.299	160
7/64	.1093	2.776	19/32	.5938	15.081	1 3/8	1.375	34.93	6 1/2	6.500	165.1
—	.1181	3	—	.6	15.240	—	1.378	35	7	7.000	177.8
1/8	.125	3.175	39/64	.6094	15.478	—	1.417	36	—	7.087	180
—	.1378	3.5	—	.6103	15.5	1 7/16	1.438	36.51	7 1/2	7.500	190.5
9/64	.1406	3.572	5/8	.6250	15.875	—	1.457	37	—	7.874	200
5/32	.1563	3.969	—	.6299	16	—	1.496	38	8	8.000	203.2
—	.1575	4	41/64	.6406	16.272	1 1/2	1.500	38.10	8 1/2	8.500	215.9
11/64	.1719	4.366	—	.6496	16.5	—	1.535	39	—	8.661	220
—	.1772	4.5	21/32	.6563	16.669	1 9/16	1.562	39.69	9	9.000	228.6
3/16	.1875	4.763	—	.6693	17	—	1.575	40	—	9.449	240
—	.1969	5	43/64	.6719	17.066	—	1.614	41	9 1/2	9.500	241.3
—	2	5.080	11/16	.6875	17.463	1 5/8	1.625	41.28	—	9.843	250
13/64	.2031	5.159	—	.6890	17.5	—	1.654	42	10	10.000	254
—	.2165	5.5	—	.7	17.780	1 11/16	1.688	42.86	—	10.236	260
7/32	.2188	5.556	45/64	.7031	17.859	—	1.693	43	11	11.000	279.4
15/64	.2344	5.953	—	.7087	18	—	1.732	44	—	11.024	280
—	.2362	6	23/32	.7188	18.256	1 3/4	1.750	44.45	—	11.811	300
1/4	.25	6.350	—	.7283	18.5	—	1.772	45	12	12.000	304.8
—	.2559	6.5	47/64	.7344	18.653	—	1.811	46	13	13.000	330.2
17/64	.2656	6.747	—	.7480	19	1 13/16	1.813	46.04	—	13.780	350
—	.2756	7	3/4	.75	19.050	—	1.850	47	14	14.000	355.6
9/32	.2813	7.144	49/64	.7656	19.447	1 7/8	1.875	47.63	15	15.000	381
—	.2953	7.5	—	.7677	19.5	—	1.890	48	—	15.748	400
19/64	.2969	7.541	25/32	.7813	19.844	—	1.929	49	16	16.000	406.4